Er. PERUMAL MANIMEKALAI COLLEGE OF ENGINEERING

(An Autonomous Institution–Affiliated to Anna University, Chennai)

Koneripalli, Hosur – 635117.

PMC TECH

INSPIRE TO INNOVATE

ACADEMIC REGULATIONS 2023 (R23)

Curriculum and Syllabi

(Version 1)

M.E. Aeronautical Engineering

(Applicable from 2023 -24 onwards)

REGULATIONS 2023 - AUTONOMOUS
CHOICE BASED CREDIT SYSTEM
M. E. AERONAUTICAL ENGINEERING

CURRICULUM AND SYLLABI FOR I TO IV SEMESTERS

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of Aeronautical Engineering through rigorous post graduate education.

II. Graduates of the programme will have successful technical and managerial career in Aeronautical Engineering industries and the allied management.

III. Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aviation industries.

PROGRAMME OUTCOMES (POs):

1. An ability to independently carry out research/investigation and development work to solve practical problems

2. An ability to write and present a substantial technical report/document

3. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

4. Post Graduate will be trained towards developing and understanding the importance of design and development of Airplanes from system integration point of view.

5. Post Graduate will exhibit the awareness of contemporary issues focusing on the necessity to develop new materials, design and testing methods for the solution of problems related to aircraft industry.

6. An understanding of professional and ethical responsibility and also capable of doing doctoral studies in multidisciplinary areas.

PROGRAM SPECIFIC OUTCOMES (PSO'S)

PSO1: Professional Skills: An Engineer capable to exploit the knowledge of Aeronautical Engineering to provide solution to real world problems and passion for innovation towards design and development of new products.

PSO2: Problem-solving skills: Use Utilization of Computer-aided Engineering packages and simulation softwares to design analyses and optimize the components of airworthiness for flight vehicles.

PEO/ POs MAPPING:

PEOs/ POs	PO1	PO2	PO3	PO4	PO5	PO6
PEO 1	3	3	2	1	2	1
PEO 2	3	3	3	1	2	2
PEO 3	3	3	3	2	1	1

AUTONOMOUS AFFILIATED COLLEGE
REGULATION 2023
CHOICE BASED CREDIT SYSTEM
M.E AERONAUTICAL ENGINEERING
CURRICULUM AND SYLLABI FOR I - IV SEMESTERS

SEMESTER - I

S. No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1	PPCC1FC01	Advanced Mathematics	FC	3	1	-	4	4
2	PPAR1PC01	Aerospace Propulsion	PC	3	-	-	3	3
3	PPAR1PC02	Flight Vehicle Aerodynamics	PC	3	1	-	4	4
4	PPAR1PC03	Analysis of Composite Structures	PC	3	-	-	3	3
5	PPCC1RM01	Research Methodology and IPR	RM	3	-	-	3	3
6	PPAR1PEXX	Professional Elective - I	PE	3	-	-	3	3
7	PPCC1ACXX	Audit Course – I*	AC	2	-	-	2	-
PRACTICALS								
8	PPAR1PL01	Aerodynamics Laboratory	PC	-	-	4	4	2
9	PPAR1PL02	Aircraft Propulsion Laboratory	PC	-	-	4	4	2
Total				20	2	8	30	24

*Registration for this course is optional to students

SEMESTER - II

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1	PPAR2PC04	Advanced Flight Dynamics	PC	3	-	-	3	3
2	PPAR2PC05	Aerospace Structures	PC	3	1	-	4	4
3	PPAR2PC06	CFD for Aerospace Applications	PC	3	-	-	3	3
4	PPAR2PC07	FEA for Aerospace Applications	PC	3	-	-	3	3
5	PPAR2PEXX	Professional Elective-II	PE	3	-	-	3	3
6	PPAR2PEXX	Professional Elective-III	PE	3	-	-	3	3
7	PPCC2ACXX	Audit Course – II*	AC	2	-	-	2	-
PRACTICALS								
8	PPAR2PL03	Aircraft Structures Laboratory	PC	-	-	4	4	2
9	PPAR2PL04	Computational Laboratory	PC	-	-	4	4	2
10	PPAR2PR01	Mini Project with Seminar	PR	-	-	4	4	2
Total				20	1	12	33	25

*Registration for this course is optional to students

SEMESTER - III

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1	PPAR3PEXX	Professional Elective-IV	PE	3	-	-	3	3
2	PPAR3PEXX	Professional Elective-V	PE	3	-	-	3	3
3		Open Elective	OE	3	-	-	3	3
PRACTICALS								
4	PPAR3PR02	Project Work Phase - I	PR	-	-	12	12	6
Total				9	-	12	21	15

SEMESTER - IV

S. No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1	PPAR4PR03	Project Work Phase - II	PR	-	-	24	24	12
Total				-	-	24	24	12
							Curriculum Total	76

SUMMARY

M.E AERONAUTICAL ENGINEERING						
S.NO	Subject Area	I	II	III	IV	Total Credits
		Credits Per Semester				
1	FC	4				4
2	PC	14	17			31
3	PE	3	6	6		15
4	OE			3		3
5	PR		2	6	12	20
6	RM	3				3
Total		24	25	15	12	76

TOTAL NUMBER OF CREDITS TO BE EARNED FOR AWARD OF THE DEGREE = 76

Abbreviations	Category
FC	Foundation Course
RM	Research Methodology and IPR
PC	Professional Core
PE	Professional Elective
OE	Open Elective
PW	Project Work
AC	Audit Course

PROFESSIONAL ELECTIVE COURSES (PEC)

SEMESTER-I, ELECTIVE –I

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1	PPAR1PE01	Theory of Vibrations	PE	3	-	-	3	3
2	PPAR1PE02	Rocketry and Space Mechanics	PE	3	-	-	3	3
3	PPAR1PE03	Computational Heat Transfer	PE	3	-	-	3	3
4	PPAR1PE04	Theory of Elasticity	PE	3	-	-	3	3
5	PPAR1PE05	Experimental Aerodynamics	PE	3	-	-	3	3
6	PPAR1PE06	Control Engineering	PE	3	-	-	3	3

SEMESTER-II, ELECTIVE–II

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1	PPAR2PE07	Structural Dynamics	PE	3	-	-	3	3
2	PPAR2PE08	Hypersonic Aerodynamics	PE	3	-	-	3	3
3	PPAR2PE09	Advanced Propulsion Systems	PE	3	-	-	3	3
4	PPAR2PE10	Aerospace Materials	PE	3	-	-	3	3
5	PPAR2PE11	Airworthiness and Air Regulations	PE	3	-	-	3	3
6	PPAR2PE12	Experimental Methods of Stress Analysis	PE	3	-	-	3	3

SEMESTER-II, ELECTIVE–III

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1	PPAR2PE13	Aeroelasticity	PE	3	-	-	3	3
2	PPAR2PE14	Theory of Boundary Layers	PE	3	-	-	3	3
3	PPAR2PE15	Combustion in Jet and Rocket Engines	PE	3	-	-	3	3
4	PPAR2PE16	Gas Dynamics	PE	3	-	-	3	3
5	PPAR2PE17	Fatigue and Fracture Mechanics	PE	3	-	-	3	3

SEMESTER-III, ELECTIVE–IV

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1	PPAR3PE18	Vibration Isolation and Control	PE	3	-	-	3	3
2	PPAR3PE19	Non-Destructive Evaluation	PE	3	-	-	3	3
3	PPAR3PE20	Component Design of Aircraft Engines	PE	3	-	-	3	3
4	PPAR3PE21	Aircraft Systems Engineering	PE	3	-	-	3	3
5	PPAR3PE22	Aircraft Design	PE	3	-	-	3	3
6	PPAR3PE23	Composite Product Processing Methods	PE	3	-	-	3	3

SEMESTER-III, ELECTIVE–V

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1	PPAR3PE24	Helicopter Aerodynamics	PE	3	-	-	3	3
2	PPAR3PE25	High Speed Jet Flows	PE	3	-	-	3	3
3	PPAR3PE26	Smart Materials and Structural Health Monitoring	PE	3	-	-	3	3
4	PPAR3PE27	Artificial Intelligence and Machine Learning	PE	3	-	-	3	3
5	PPAR3PE28	Aircraft Guidance and Control	PE	3	-	-	3	3

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S.No	Course Code	Course Name	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1	PPCC1AC01	English for Research Paper Writing	AC	2	-	-	2	0
2	PPCC1AC02	Disaster Management	AC	2	-	-	2	0
3	PPCC2AC01	Constitution of India	AC	2	-	-	2	0
4	PPCC2AC02	நற்றமிழ் இலக்கியம்	AC	2	-	-	2	0

PPFC1AS01	ADVANCED MATHEMATICS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

1	To attain the knowledge of solving Partial Differential Equations using Laplace transform
2	To apply Fourier Transform to solve boundary value problems
3	To achieve maxima and minima of a functional
4	To acquire knowledge on using conformal mapping to fluid flow and heat flow problems
5	To understand the tensor analysis as a tool to solve problems arising in engineering disciplines

UNIT – I	LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS	12

Laplace transform: Definitions – Properties – Transform error function – Bessel's function - Dirac delta function – Unit step functions – Convolution theorem – Inverse Laplace transform: Complex inversion formula – Solutions to partial differential equations: Heat equation – Wave equation.

UNIT – II	FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS	12

Fourier transform: Definitions – Properties – Transform of elementary functions – Dirac delta function – Convolution theorem – Parseval's identity – Solutions to partial differential equations: Heat equation – Wave equation – Laplace and Poisson's equations

UNIT – III	CALCULUS OF VARIATIONS	12

Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems – Direct methods – Ritz and Kantorovich methods.

UNIT – IV	CONFORMAL MAPPING AND APPLICATIONS	12

Introduction to conformal mappings and bilinear transformations – Schwarz Christoffel transformation –Transformation of boundaries in parametric form – Physical applications: Fluid flow and heat flow problems.

UNIT – V	TENSOR ANALYSIS	12

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient- Divergence and curl.

TOTAL: 60 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Application of Laplace and Fourier transforms to initial value, initial–boundary value and boundaryvalue problems in Partial Differential Equations	Evaluating
CO2	Maximizing and minimizing the functional that occur in various branches of EngineeringDisciplines	Evaluating
CO3	Construct conformal mappings between various domains and use of conformal mapping in studying problems in physics and engineering particularly to fluid	Applying

	flow and heat flow problems	
CO4	Understand tensor algebra and its applications in applied sciences and engineering and develops ability to solve mathematical problems involving tensors	Analyzing
CO5	Competently use tensor analysis as a tool in the field of applied sciences and related fields	Analyzing

REFERENCE BOOKS:

1	Andrews L.C. and Shivamoggi, B., "Integral Transforms for Engineers", Prentice Hall of IndiaPvt. Ltd., New Delhi, 2013
2	Elsgolc, L.D., "Calculus of Variations", Dover Publications Inc., New York, 2007
3	Mathews, J. H., and Howell, R.W., "Complex Analysis for Mathematics andEngineering",6th Edition, Jones and Bartlett Publishers, 2012
4	Kay, D. C., "Tensor Calculus", Schaum's Outline Series, Tata McGraw Hill Edition,2014
5	Naveen Kumar, "An Elementary Course on Variational Problems in Calculus ", Narosa Publishing House, 2005

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://link.springer.com/chapter/10.1007/978-3-642-04311-6_8
2	https://sites.ualberta.ca/~niksirat/PDE/chapter-9pde.pdf
3	https://en.wikipedia.org/wiki/Calculus_of_variations
4	https://www.britannica.com/science/tensor-analysis

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR1PC01	AEROSPACE PROPULSION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To gain knowledge on fundamental principles of aircraft and rocket propulsion
2	To describe various types of propulsion system with their merits and challenges.
3	To gain adequate knowledge on propellers and its characteristics.
4	To be familiar with the working concept of inlets, nozzles and combustion chamber with theirapplications in a propulsion system.
5	To gain sufficient information about compressors and turbines. Students also will get an exposureon electric propulsion methods

UNIT – I	ELEMENTS OF AIRCRAFT PROPULSION	9

Classification of power plants – Methods of aircraft propulsion – Propulsive efficiency – Specific fuelconsumption – Thrust and power- Factors affecting thrust and power- Illustration of working of piston engines and Gas turbine engines – Characteristics of piston engine, turboprop, turbofan and turbojet engines, Ram jet, Scram jet – Methods of Thrust augmentation.

UNIT – II	PROPELLER THEORY	9

Momentum theory, Blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters, prediction of static thrust- and in flight, negative thrust,prop fans, ducted propellers, propeller noise, propeller selection, propeller charts.

UNIT – III	INLETS, NOZZLES AND COMBUSTION CHAMBERS	9

Subsonic and supersonic inlets – Relation between minimum area ratio and external deceleration ratio –Starting problem in supersonic inlets –Modes of inlet operation, jet nozzle – Efficiencies – Over expanded, under and optimum expansion in nozzles – Thrust reversal. Classification of Combustion chambers – Combustion chamber performance – Flame tube cooling – Flame stabilization

UNIT – IV	AXIAL FLOW COMPRESSORS, FANS AND TURBINES	9

Introduction to centrifugal compressors- Axial flow compressor- geometry- twin spools- three spools- stage analysis- velocity polygons- degree of reaction – radial equilibrium theory- performance maps- axial flow turbines- geometry- velocity polygons- stage analysis- performance maps- thermal limit of blades and vanes.

UNIT – V	ROCKET AND ELECTRIC PROPULSION	9

Introduction to rocket propulsion – Reaction principle – Thrust equation – Classification of rockets based on propellants used – solid, liquid and hybrid – Comparison of these engines with special reference to rocket performance – electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hall thrusters.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Get exposure with the different types of propulsive devices used for jet and rocket propulsion	Remembering
CO2	Have knowledge on propeller theory and its performance parameters	Remembering
CO3	Be able to distinguish different types of inlets and their performance trends in subsonic andsupersonic flows	Remembering

CO4	Be able to describe the process of combustion and the parameters that affect combustion in jetengines	Analyzing
CO5	Be able to acquire knowledge on the basic concepts of various types of electric propulsion systems	Analyzing

REFERENCE BOOKS:

1	Hill, PG. & Peterson, CR. "Mechanics & Thermodynamics of Propulsion" Pearson education, 2ndedition, 2014
2	Cohen, H, Saravanamuttoo, HIH., Rogers, GFC, Paul Straznicky and Andrew Nix , "Gas Turbine Theory", Pearson Education Canada; 7th edition, 2017.
3	Gill,WP, Smith,HJ & Ziurys,JE, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980
4	Oates, GC,"Aerothermodynamics of Aircraft Engine Components", AIAA Education Series, 2007
5	Sutton, GP, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2017

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://ftp.idu.ac.id/wpcontent/uploads/ebook/tdg/DESIGN%20SISTEM%20DAYA%20GERAK/Elements%20of%20Propulsion,%20Gas%20Turbines%20and%20Rockets%202nd%20edition.pdf
2	https://en.wikipedia.org/wiki/Propeller_theory
3	https://en.wikipedia.org/wiki/Combustor
4	https://www.sciencedirect.com/topics/engineering/axial-flow-compressors

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	1	2
CO2	3	2	2	2	1	2
CO3	3	2	2	2	2	2
CO4	3	2	2	2	2	2
CO5	3	2	1	2	1	2

AR12

PPAR1PC02	FLIGHT VEHICLE AERODYNAMICS	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

1	To gain insights into the basics of fluid flow, its model and tool to solve the fluid flow problems
2	To be familiar with the conservation laws of fluid dynamics, and how to apply them to practicalfluid flows
3	To gain knowledge on elementary flows to combine and form realistic flows with suitableassumptions
4	To analyse incompressible flow over three-dimensional bodies like wing and so on
5	To gain knowledge on the basic concepts of viscous flows, boundary layers to practical flows

UNIT – I	INTRODUCTION TO AERODYNAMICS	12

Aerodynamic force and moments, lift and Drag coefficients, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Continuity and Momentum equations, Point source and sink, doublet, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocitydistributions on bodies with and without circulation in ideal and real fluid flows, Magnus effect.

UNIT – II	INCOMPRESSIBLE FLOW THEORY	12

Conformal Transformation, Karman ,Trefftz profiles, Kutta condition, Kelvin's Circulation Theorem and the Starting Vortex, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot– Savartlaw, lifting line theory, effect of aspect ratio.

UNIT – III	COMPRESSIBLE FLOW THEORY	12

Compressibility, Isentropic flow through nozzles, Normal shocks, Oblique and Expansion waves, Moving shock waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, Small perturbation theory, Prandtl- Glauert Rule, Linearized supersonic flow, Method of characteristics.. Classification of Combustion chambers – Combustion chamber performance – Flame tube cooling – Flame stabilization

UNIT – IV	AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS	12

Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, transonic area rule, Swept wings (ASW and FSW), Supersonic airfoils, Shock-Expansion Theory, Wave drag, Delta wings.

UNIT – V	VISCOUS FLOW THEORY	12

Basics of viscous flow theory, Boundary Layer,Flow separation, Displacement, momentum and Energy Thickness, Laminar and Turbulent boundary layers ,Boundary layer over flat plate, Blasius Solution, Estimation of skin friction drag in laminar and turbulent flow, The Reference Temperature Method.

TOTAL: 60 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Comprehend the behaviour of airflow over bodies with particular emphasis on airfoil sections in theincompressible flow regime	Remembering
CO2	Be able to solve inviscid, incompressible and irrotational flows	Applying
CO3	Be able to apply the conservation equations for fluid flows.	Applying

CO4	Be provided with the knowledge on thermodynamic state of the gas behind normal shock waves,oblique shock waves and expansion waves	Analyzing
CO5	Be provided with adequate knowledge on the basic concepts of laminar and turbulent boundarylayers.	Analyzing

REFERENCE BOOKS:

1	J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill Education, 6th edition, 2017
2	Rathakrishnan.E, Gas Dynamics, Prentice Hall of India, 7th edition, 2020
3	Shapiro, AH, "Dynamics & Thermodynamics of Compressible Fluid Flow",Ronald Press, 1982.
4	Houghton, EL and Caruthers, NB, "Aerodynamics for Engineering Students",Butterworth-Heinemann series, 7th edition 2017
5	Zucrow, M.J, and Anderson, J.D, "Elements of gas dynamics" McGraw-HillBook Co., NewYork, 1989.

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://eng.libretexts.org/Bookshelves/Aerospace_Engineering/Aerodynamics_and_Aircraft_Performance_(Marchman)/01%3A_Introduction_to_Aerodynamics
2	https://archive.nptel.ac.in/courses/101/105/101105059/
3	https://en.wikipedia.org/wiki/Aerodynamics
4	https://en.wikipedia.org/wiki/Spacecraft_electric_propulsion

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	3	1	3	1
CO2	-	-	3	1	2	1
CO3	-	-	3	1	2	1
CO4	-	-	3	1	1	1
CO5	-	-	3	1	2	1

AR14

PPAR1PC03	ANALYSIS OF COMPOSITE STRUCTURES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To impart knowledge on the macro mechanics of composite materials
2	To determine stresses and strains in composites and also imparts an idea about the manufacturingmethods of composite materials
3	To get an idea on failure theories of composites
4	To provide the basic knowledge on the properties of fibre and matrix materials used in commercial composites as well as some common manufacturing techniques
5	To gain knowledge on the basic concepts of acoustic emission technique

UNIT – I	FIBERS, MATRICES, AND FABRICATION METHODS	9

Production & Properties of Glass, Carbon and Aramid Fibers – Thermosetting and Thermoplastic Polymers – Polymer Properties of Importance to the Composite, Summary of Fabrication Processes –Scope of Composite Materials for Various Aerospace Applications.

UNIT – II	MICROMECHANICS OF A UNIDIRECTIONAL COMPOSITE	9

Volume and Weight Fractions in a Composite Specimen – Longitudinal Behaviour of UnidirectionalComposites – Load Sharing – Failure Mechanism and Strength – Factors Influencing Longitudinal Strength and Stiffness – Transverse Stiffness and Strength – Prediction of Elastic Properties Using Micromechanics –Typical Unidirectional Fiber Composite Properties – Minimum and Critical Fiber
Volume Fractions.

UNIT – III	MACROMECHANICS APPROACH	9

Stress Analysis of an Orthotropic Lamina-Hooke's Law-Stiffness and Compliance Matrices - Specially Orthotropic Material-Transversely Isotropic Material & Specially Orthotropic Material under Plane
Stress-Determination of Ex, Ey, Gxy-Stress & Strain Transformations- Transformation of Stiffness and Compliance Matrices-Strengths of an Orthotropic Lamina Using Different Failure Theories

UNIT – IV	ANALYSIS OF LAMINATED COMPOSITES	9

Laminate Strains - Variation of Stresses in a Laminate - Resultant Forces and Moments - Synthesis of Stiffness Matrix - Laminate Description System - Construction and Properties of Special Laminates - Symmetric Laminates – Balanced Laminate - Cross-Ply, and Angle-Ply Laminates - Quasi-isotropic Laminates - Determination of Laminae Stresses and Strains – Determination of Hygrothermal Stresses -Analysis of Laminates after Initial Failure.

UNIT – V	ANALYSIS OF LAMINATED PLATES AND BEAMS	9

Governing Equations For Laminated Composite Plates -- Governing Equations for Laminated Beams - Application of Theory – Bending, Buckling and Vibration of Laminated Beams and Plates repair-Analysis of sandwich construction-AE technique.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To calculate the elastic and strength properties of unidirectional laminates using micromechanicstheory	Applying
CO2	To analyse a composite laminate using the different failure theories	Analyzing
CO3	To select the most appropriate manufacturing process for fabricating composite components	Remembering

CO4	To demonstrate understanding of the different materials (fibres, resins, cores) used in composites	Understanding
CO5	To gain knowledge on non-destructive inspection (NDI) and structural health monitoring of composites	Analyzing

REFERENCE BOOKS:

1	Autar K Kaw, "Mechanics of Composite Materials", CRC Press, 2nd edition, 2015
2	Agarwal, BD and Broutman, LJ, "Analysis and Performance of Fibre Composites", John Wiley& Sons, 3rd edition, 2006
3	Calcote, LR, "The Analysis of laminated Composite Structures", Von –Nostrand Reinhold Company, New York, 1998
4	Isaac M. Daniel &OriIshai, " Mechanics of Composite Materials", OUP USApublishers, 2nd edition, 2005
5	Lubing, "Handbook on Advanced Plastics and Fibre Glass", Von Nostran ReinholdCo., NewYork, 1989

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://www.compositesworld.com/articles/fabrication-methods
2	https://www.degruyter.com/document/doi/10.1515/secm-2016-0088/html?lang=en
3	http://ethesis.nitrkl.ac.in/5878/1/110ME0335-6.pdf
4	http://www.ae.iitkgp.ac.in/ebooks/chapter7.html

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	3	1
CO2	2	-	2	-	3	1
CO3	-	-	2	-	2	1
CO4	-	-	2	-	2	1
CO5	-	-	2	-	1	1

PPCC1RM01	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To understand the research design
2	To know data collection and sources
3	To aware data analysis and reporting
4	To understand the concepts of Intellectual Property Rights
5	To know the objectives and benefits of Patent

UNIT – I	RESEARCH DESIGN	9

Overview of research process and design, Use of Secondary and exploratory data to answer the researchquestion, Qualitative research, Observation studies, Experiments and Surveys.

UNIT – II	DATA COLLECTION AND SOURCES	9

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data -Preparing, Exploring, examining and displaying

UNIT – III	DATA ANALYSIS AND REPORTING	9

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insightsand findings using written reports and oral presentation

UNIT – IV	INTELLECTUAL PROPERTY RIGHTS	9

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPRestablishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement,Trademark, Functions of UNESCO in IPR maintenance

UNIT – V	PATENTS	9

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To calculate the elastic and strength properties of unidirectional laminates using micromechanicstheory	Applying
CO2	To analyse a composite laminate using the different failure theories	Analyzing
CO3	To select the most appropriate manufacturing process for fabricating composite components	Remembering
CO4	To demonstrate understanding of the different materials (fibres, resins, cores) used in composites	Analyzing

CO5	To gain knowledge on non-destructive inspection (NDI) and structural health monitoring of composites	Remembering

REFERENCE BOOKS:

1	Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", TataMcGraw Hill Education, 11e (2012).
2	Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights,Trade Secrets", Entrepreneur Press, 2007
3	David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools &techniques", Wiley,2007
4	The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://emeritus.org/in/learn/types-of-research-design/
2	https://www.analyticsvidhya.com/blog/2022/03/an-overview-of-data-collection-data-sources-and-data-mining/
3	https://en.wikipedia.org/wiki/Intellectual_property
4	https://www.wipo.int/patents/en/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	-	3	1
CO2	2	-	2	-	3	1
CO3	-	-	2	-	2	1
CO4	-	-	2	-	2	1
CO5	-	-	2	-	1	1

PPAR1PL01	AERODYNAMICS LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1	To gain knowledge on the principles of subsonic wind tunnel and their operation
2	To acquire practical knowledge on various aerodynamic principles related to inviscid incompressible fluids.
3	To calculate various aerodynamic characteristics of various objects
4	To characterize laminar and turbulent flows
5	To get practical exposure on flow visualization techniques pertaining to subsonic flows

LIST OF EXPERIMENTS

1. Calibration of subsonic wind tunnel.
2. Pressure distribution over a smooth cylinder.
3. Pressure distribution over a rough cylinder.
4. Pressure distribution over a symmetric aerofoil section.
5. Pressure distribution over a cambered aerofoil section.
6. Pressure distribution over a wing of cambered aerofoil section.
7. Study on Force and moment measurements by using strain gauge.
8. Wake measurements behind a bluff body.
9. Velocity boundary layer measurements over a flat plate.
10. Force and moment measurements on aircraft model by using strain gauge.
11. Force and Moment measurements using wind tunnel balance.
12. Subsonic flow visualization studies.

Any 10 experiments may be conducted.

LABORATORY EQUIPMENTS REQUIRED

1. Subsonic wind tunnel
2. Rough and smooth cylinder
3. Symmetrical and Cambered aerofoil
4. Wind tunnel balance
5. Pressure Transducers
6. Blower
7. Testing models like flat plate, bluff body

TOTAL: 60 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Able to operate and calibrate subsonic wind tunnel	Applying
CO2	Able to analyse the pressure distribution over the streamlined and bluff bodies	Applying
CO3	Able to carry out measurement of force and moments on aircraft models	Analyzing
CO4	Capable of measuring boundary layer thickness over various models	Analyzing
CO5	Able to carry out flow visualization at subsonic speeds	Analyzing

CO-PO MAPPING						
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	-	3	1
CO2	3	1	2	-	3	1
CO3	3	1	2	-	3	1
CO4	3	1	2	-	3	1
CO5	3	1	2	-	3	1

AR20

PPAR1PL02	AIRCRAFT PROPULSION LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1	To gain knowledge on wall pressure distribution on subsonic inlets and nozzles
2	To perform testing on compressor blades
3	To interpret the experimental data using software
4	To get practical exposure on flow visualization techniques pertaining to supersonic jets
5	To gain basic knowledge on cold flow studies

LIST OF EXPERIMENTS

1. Wall pressure measurements of a subsonic diffuser.
2. Cascade testing of compressor blades.
3. Pressure distribution on a cavity model.
4. Wall pressure measurements on non-circular combustor.
5. Wall pressure measurements on converging nozzle.
6. Wall pressure measurements on convergent-divergent nozzle.
7. Total pressure measurements along the jet axis of a circular subsonic jet.
8. Total pressure measurements along the jet axis of a circular supersonic jet.
9. Total pressure measurements in the radial direction of the subsonic jet.
10. Total pressure measurements in the radial direction of the supersonic jet.
11. Cold flow studies of a wake region behind flame holders.
12. Prediction of flow angles using angle probe.

Any 10 experiments may be conducted.

LABORATORY EQUIPMENTS REQUIRED

1. Subsonic wind tunnel
2. High speed jet facility
3. Blower
4. Pressure scanner
5. Nozzle and cavity models

TOTAL: 60 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Able to perform wall pressure distribution on subsonic and supersonic nozzles	Analyzing
CO2	Able to acquire knowledge on fundamental concepts of low speed jets and experimental techniquespertain to measurements	Analyzing
CO3	Provided with adequate knowledge on pressure distribution on cavity models	Analyzing
CO4	Able to perform wake survey methods	Analyzing
CO5	Able to carry out flow visualization on subsonic jets	Analyzing

CO-PO MAPPING						
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	2	2	-	2	1
CO2	3	2	2	-	2	1
CO3	3	2	2	-	2	1
CO4	3	2	2	-	2	1
CO5	3	2	2	-	2	1

PPAR2PC04	ADVANCED FLIGHT DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To gaining depth knowledge on aircraft performance in level, climbing, gliding flight modes
2	To get familiarize the equations of motion in accelerated flight modes
3	To impart knowledge on the basic aspects of stability and control of an airplane about three axis
4	To provide adequate knowledge on various parameters that decide the stability level of an airplane
5	To be familiar with the aspects of control in longitudinal, lateral and directional modes

UNIT – I	STEADY FLIGHT PERFORMANCE	9

Overview of Aerodynamics and ISA – Straight and level flight: thrust and power required/available, differences of propeller-driven and jet-powered airplanes, maximum speed, effects of altitude – Climb and Descent performance: climb angle and rate of climb, descent angle and rate of descent – Range, endurance of propeller driven and jet powered airplanes.

UNIT – II	MANEUVER PERFORMANCE	9

Level turn – maximum producible load factor – fastest and tightest turn – Vertical maneuver: pull- up and pull-out, pull-down – gust V-n diagram –Take-off and landing performance.

UNIT – III	STATIC LONGITUDINAL STABILITY AND CONTROL	9

Static equilibrium and stability – Pitch stability of conventional and canard aircraft – control fixed neutral point and static margin – effect of fuselage and running propellers on pitch stability – control surface hinge moment – control free neutral point – limit on forward CG travel –maneuver stability: Pull –up & level turn – control force and trim tabs – control force for maneuver– measurement of neutral point and maneuver point by flight tests.

UNIT – IV	STATIC LATERAL, DIRECTIONAL STABILITY AND CONTROL	9

Yaw and side slip, effect of wing sweep, wing dihedral and vertical tail on directional stability – rudder fixed and rudder free – yaw control – rudder sizing – pedal force - dihedral effect: contribution of variouscomponents- roll control.

UNIT – V	AIRCRAFT DYNAMICS	9

Rigid body equations of motion - Axes systems and their significance – Euler angles – linearization of longitudinal equations – force and moment derivatives – short period and phugoid approximations – purepitching motion – linearization of equations for lateral – directional motion – roll, spiral and dutch roll approximations- Pure rolling- Pure yawing – Inertia coupling.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Be able to assess the performance of aircraft in steady and maneuver flights.	Remembering
CO2	Have thorough knowledge in order to perform preliminary design computations to meet staticstability and trim requirements of aircrafts	Analyzing
CO3	Be able to determine the fixed neutral point and the stick fixed static margin	Remembering

CO4	Be able to describe the effect of change in CG on the aircraft stability	Analyzing
CO5	Apply the small disturbance equations of motion, and identify longitudinal and lateral sets ofequations, construct state space models for longitudinal and lateral aircraft dynamics	Analyzing

REFERENCE BOOKS:

1	Perkins CD &Hage, RE, "Airplane performance, stability and control", Wiley India Pvt Ltd, 2011
2	Anderson, JD, "Aircraft Performance & Design", First edition, Mc Graw Hill India,2010
3	McCormick, BW, "Aerodynamics, Aeronautics, & Flight Mechanics", 2nd edition, John Wiley& Sons, 1995
4	Michael V. Cook, "Flight Dynamics Principles", Second edition, Elsevier, 2007
5	Nelson, RC, "Flight Stability & Automatic Control", Second edition, McGraw-Hill,2017

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://en.wikipedia.org/wiki/Steady_flight#:~:text=Steady%20flight%2C%20unaccelerated%20flight%2C%20or,a%20body%2Dfixed%20reference%20frame.
2	https://www.globalspec.com/reference/43619/203279/chapter-10-maneuver-performance
3	https://apps.dtic.mil/sti/tr/pdf/ADA319976.pdf
4	https://en.wikipedia.org/wiki/Aircraft_flight_dynamics

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	2	-	1
CO2	1	1	2	2	2	1
CO3	1	1	2	2	3	1
CO4	2	2	2	2	1	1
CO5	2	1	2	3	-	1

AR24

PPAR2PC05	AEROSPACE STRUCTURES	L	T	P	C
		3	1	0	4

COURSE OBJECTIVES:

1	To gain important technical aspects on the theory of bending of structures.
2	To learn the key aspects of shear flow in open and closed sections.
3	To study the stability problems in structures with various modes of loading.
4	To analyse aircraft structural components under various forms of loading.
5	To have basic idea about the importance of flight envelope

UNIT – I	BENDING OF BEAMS	12

Shear flow in thin-walled closed sections – Symmetrical and unsymmetrical sections – Flexural shear flow in two flange, three flange and multi-flange box beams – Determinations of the shear centre – Bredt-Batho theory – Torsional shear flow in multi-cell tubes – Shear flow due to combined bending and torsion – Stress analysis of aircraft components – Tapered wing spar – Introduction to shear lag

UNIT – II	SHEAR FLOW IN THIN-WALLED SECTION	12

General stress, strain and displacement relationships for open section thin-walled beams – Concept of shear flow – Shear flow in thin walled open sections – Determinations of the shear centre – Symmetricaland unsymmetrical cross-sections – Shear flow due to bending in open sections – Torsion of thin-walled open section members & determination of stresses – Design of thin-walled members

UNIT – III	SHEAR FLOW IN CLOSED SECTIONS	12

Shear flow in thin-walled closed sections – Symmetrical and unsymmetrical sections – Flexural shear flow in two flange, three flange and multi-flange box beams – Determinations of the shear centre – Bredt-Batho theory – Torsional shear flow in multi-cell tubes – Shear flow due to combined bending and torsion – Stress analysis of aircraft components – Tapered wing spar – Introduction to shear lag.

UNIT – IV	STABILITY PROBLEMS	12

Stability problems of thin walled structures – Buckling of sheets under compression, shear, and combined loads – Plate buckling coefficient – Inelastic buckling of plates – Sheet-stiffener panels– Effective width – Failure stress in plates and stiffened panels – Crippling stress estimation – Local Buckling – Wagner beam theory – Experimental determination of critical load for a flat plate– Principles of stiffener/web construction.

UNIT – V	ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS	12

Aircraft Loads – Symmetric manoeuvre loads – Load factor determination – Inertia loads – Aerodynamicloads & Schrenk's curve – The flight envelope – Shear force, bending moment and torque distribution along the span of the wing and fuselage – Structural parts of wing and fuselage and their functions – Analysis of rings and frames — Introduction to Aeroelasticity and shells.

TOTAL: 60 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Apply the concept of normal stress variation in unsymmetrical sections subject to bendingmoments	Applying
CO2	Find the shear flow variation in thin walled open sections with skin effective and ineffective inbending.	Analyzing

CO3	Evaluate the shear flow variation in single cell and multi-cell tubes subjected to shear and torqueloads.	Evaluating
CO4	Analyse the behaviour of buckling of simply supported plates and also to know the effective widthof sheet stringers combination	Analyzing
CO5	Analyse and design structural members subject to compression	Analyzing

REFERENCE BOOKS:

1	Bruhn. EF, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 2010.
2	Bruce. K. Donaldson, "Analysis of Aircraft Structures: An Introduction", CambridgeUniversity Press, 2nd edition, 2012.
3	Megson, TMG, "Aircraft Structures for Engineering Students", Elsevier, Aerospace Engineering, Series, 7th Edition, 2021
4	Peery, DJ. And Azar, JJ, "Aircraft Structures", 2nd Edition, McGraw-Hill, New York,1993
5	Rivello, R.M, "Theory and Analysis of Flight structures", McGraw-Hill, N.Y., 1993

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://www.princeton.edu/~humcomp/bikes/design/desi_63.htm#:~:text=Bending%20of%20Beams&text=The%20pure%20bending%20shown%20in,illustrated%20in%20(b)%20opposite.
2	https://en.wikipedia.org/wiki/Shear_flow#:~:text=An%20equivalent%20definition%20for%20shear,per%20foot%20in%20the%20US.
3	https://www.slideshare.net/SaikatMondal37/stability-problem
4	https://iopscience.iop.org/article/10.1088/1757899X/149/1/012127/pdf#:~:text=The%20basic%20methods%20involved%20in,to%20specified%20loads%20and%20actions.

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	3	2	2	1
CO2	-	-	3	2	3	1
CO3	-	-	3	2	3	1
CO4	-	-	3	2	2	1
CO5	-	-	3	2	2	1

PPAR2PC06	CFD FOR AEROSPACE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get familiarize with the procedure to obtain numerical solution to fluid dynamic problems.
2	To gain knowledge on the important aspects of grid generation for practical problems.
3	To get exposure on time dependant and panel methods.
4	To learn the techniques pertaining to transonic small perturbation force.
5	To make use of commercial CFD software for aerospace applications.

UNIT – I	NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS	9

Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, mathematical properties of fluid dynamic equations and classification of partial differential equations - Finding solution of a simple gas dynamic problem, Local similar solutions ofboundary layer equations, Numerical integration and shooting technique. Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations- Panel methods.

UNIT – II	GRID GENERATION	9

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries. Elliptic grid generation using Laplace's equations for geometries like aerofoil and CD nozzle. Unstructured grids, Cartesian grids, hybrid grids, grid around typical 2D and 3D geometries –Overlapping grids – Grids around multi bodies.

UNIT – III	TIME DEPENDENT METHODS	9

Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Some time dependent solutions of gas dynamic problems. Numerical solution of unsteady 2-D heat conduction problems using SLOR methods.

UNIT – IV	FINITE VOLUME METHOD	9

Introduction to Finite volume Method - Different Flux evaluation schemes, central, upwind and hybrid schemes - Staggered grid approach - Pressure-Velocity coupling - SIMPLE, SIMPLER algorithms- pressure correction equation (both incompressible and compressible forms) - Application of Finite Volume Method -artificial diffusion

UNIT – V	CFD FOR INDUSTRIAL APPLICATIONS	9

Various levels of approximation of flow equations, turbulence modelling for viscous flows, verification and validation of CFD code, application of CFD tools to 2D and 3D configurations. CFD for kinetic heating analysis – Coupling of CFD code with heat conduction code, Unsteady flows – Grid movement method, Oscillating geometries, Computational Aeroelasticity – Coupling of CFD with structural model –Aeroelasticity of airfoil geometry, Introduction to commercial CFD software for aerospace applications, High performance computing for CFD applications – Parallelization of codes – domain decomposition.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To arrive at the numerical solutions to boundary layer equations	Remembering
CO2	To perform numerical grid generation and have knowledge about the mapping	Evaluating

	techniques ineffective inbending.	
CO3	To familiarise himself/herself with high performance computing for CFD applications.	Remembering
CO4	To implement the explicit time dependent methods and their factorization schemes	Analyzing
CO5	To do the stability analysis and linearization of the implicit methods	Analyzing

REFERENCE BOOKS:

1	Chung. TJ, "Computational Fluid Dynamics", Cambridge University Press, 2010
2	Bose. TK, "Numerical Fluid Dynamics", Narosa Publishing House, 2001.
3	Hirsch, AA, "Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989
4	John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017
5	SedatBiringen&Chuen-Yen Chow, "Introduction to Computational Fluid Dynamics by Example", Wiley publishers, 2nd edition, 2011

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://digital.library.adelaide.edu.au/dspace/bitstream/2440/21002/2/02whole.pdf
2	https://www.sciencedirect.com/topics/engineering/grid-generation

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	2	2	1	1	1
CO2	2	2	3	1	2	1
CO3	2	1	3	1	1	1
CO4	2	2	3	1	2	1
CO5	2	2	2	1	1	1

PPAR2PC07	FEA FOR AEROSPACE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To learn the concepts of finite element methods and the various solution schemes available.
2	To impart knowledge to solve plane stress and plane strain problems.
3	To solve heat transfer and fluid mechanics problems using Finite element methods.
4	To formulate mass and stiffness element matrices for vibration problems.
5	To be familiar in obtaining solutions to fluid flow problems.

UNIT – I	INTRODUCTION	9

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods – Problem Formulation – Application to Structural Elements & Practical Problems – Derivation of Stiffness and Flexibility Matrices – Spring Systems – Role of Energy Principles – Basic Concepts ofFinite Element Method – Interpolation, Nodes, Degrees of Freedom – Solution Schemes

UNIT – II	DISCRETE ELEMENTS	9

Finite Element Structural Analysis Involving 1-D Bar and Beam Elements – Tapered Bar – TemperatureEffects – Static Loading – Formulation of the Load Vector for 1-D Elements – Methods of Stiffness Matrix Formulation – Interpolation & Shape Functions – Boundary Conditions–Determination of Displacements & Reactions – Constitutive Relations – Determination of Nodal Loads & Stresses

UNIT – III	CONTINUUM ELEMENTS	9

Plane Stress & Plane strain Loading – CST Element – LST Element – Element Characteristics – ProblemFormulation & Solution Using Finite Elements – Axisymmetric Bodies & Axisymmetric Loading – Consistent and Lumped Load Vectors – Use of Local, Area and Volume Co-ordinates – Isoparametric Formulation – Shape Functions – Role of Numerical Integration – Load Consideration – Complete FE Solution

UNIT – IV	VIBRATION & BUCKLING	9

Formulation of the Mass and Stiffness Element Matrices for Vibration Problems – Bar and Beam Elements – Derivation of the Governing Equation – Natural Frequencies and Modes – Damping Considerations –Harmonic Response – Response Calculation Using Numerical Integration – Buckling of Columns – Problem Formulation – Solution – Determination of Buckling Loads and Modes.

UNIT – V	HEAT TRANSFER & FLUID MECHANICS PROBLEMS	9

One Dimensional Heat Transfer Analysis – Formulation of the Governing Equations in Finite Element Form – Equivalent Load Vector – Solution & Temperature Distribution – Finite Element Formulation & Solution for Sample Problems Involving Fluid Mechanics .

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	An ability to frame governing equations involving different type of finite elements	Remembering
CO2	Knowledge on the general finite element methodology for a variety of practical problems	Remembering
CO3	An ability to solve simple 1-D and 2-D problems using the finite element method	Remembering

CO4	Knowledge on how to apply numerical integration techniques effectively in finite elementssolutions.	Analyzing
CO5	Ability to frame and solve heat transfer and fluid mechanics problems using the FE method	Analyzing

REFERENCE BOOKS:

1	Dhanaraj, R &K.PrabhakaranNair, K, Finite Element Method, Oxford university press, India,2015
2	Bathe, KJ &Wilson,EL, Numerical Methods in Finite Elements Analysis, Prentice Hall ofIndia Ltd., 1983.
3	Krishnamurthy, CS, Finite Elements Analysis, Tata McGraw – Hill, 1987
4	Rao, SS Finite Element Method in Engineering, Butterworth, Heinemann Publishing, 3rd Edition, 1998
5	Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt, Concepts andApplications of Finite Element Analysis, John Wiley & Sons, 4th Edition, 2002

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/112/104/112104302/
2	https://courses.ansys.com/index.php/courses/structures-in-aerospace/
3	https://nptel.ac.in/courses/112103298

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	3	-	2	1
CO2	1	2	2	-	2	1
CO3	2	2	3	-	3	1
CO4	1	2	3	-	3	1
CO5	2	2	3	-	3	1

PPAR2PL03	AIRCRAFT STRUCTURES LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1	To get practical knowledge on calibration of photoelastic materials.
2	To gain practical exposures on calculating shear centre locations for closed and open sections.
3	To provide with the basic knowledge of fabricating a composite laminate.
4	To have basic knowledge on unsymmetrical bending of beams.
5	To design and conduct different types of practical tests involving various aircraft structuralcomponents.

LIST OF EXPERIMENTS

1. Calibration of photo elastic materials
2. Experimental modal analysis
3. Forced vibration testing
4. Fabrication and static testing of composite laminates
5. Non-destructive evaluation of defects in composite laminates using acoustic emission
6. Non-destructive evaluation of defects in composite laminates using ultrasonic.
7. Whirling of composite shafts
8. Unsymmetrical bending of beams
9. Determination of influence coefficients and flexibility matrix
10. Shear centre location for open & closed thin-walled sections
11. Buckling of columns with different end conditions
12. Experimental verification of the Wagner beam theory

Any 10experiments will be conducted out of 12.

LABORATORY EQUIPMENTS REQUIRED

1. Electrical resistance strain gauges installation kit.
2. Circuit board with resistors, wires, clips, and strain gauges.
3. Column testing set-up (with provision for different end conditions)
4. Unsymmetrical beam bending set-up.
5. Dial gauges & travelling microscope.
6. Experimental setup for location of shear centre (open & closed sections)
7. Whirling of shafts demonstration unit.
8. Photo-elastic models.
9. Equipment for the fabrication of composite laminates.
10. Testing instruments and equipment for ultrasonic testing.
11. Diffuser transmission type polariscope with accessories
12. Experimental setup for vibration of beams& vibration measuring instruments.
13. Universal Testing Machine.
14. Wagner beam & accessories.

TOTAL: 60 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To conduct tests and interpret data involving strain gauges	Analyzing
CO2	To get exposure on experimental methods in photoelasticity	Analyzing

CO3	To design an experimental evaluation technique for a given application	Analyzing
CO4	To comprehend non-destructive testing methods	Analyzing
CO5	To fabricate of composite laminates and characterizes it	Analyzing

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	-	2	1
CO2	3	2	2	-	2	1
CO3	3	2	2	-	2	1
CO4	3	2	2	-	2	1
CO5	3	2	2	-	2	1

PPAR2PL04	COMPUTATIONAL LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

1	This course is intended to make students familiar with different types of structural analysis usingfinite element software
2	This course helps students to correctly interpret the results of simulation.
3	To equip with the knowledge base essential for application of computational fluid dynamics toengineering flow problems.
4	To provide the essential numerical background for solving the partial differential equationsgoverning the fluid flow.
5	To develop students' skills of using a commercial software package

LIST OF EXPERIMENTS

1. Numerical simulation of 1-D diffusion and conduction in fluid flows
2. Numerical simulation of 1-D convection-diffusion problems
3. Numerical simulation of 2-D unsteady state heat conduction problem
4. Numerical simulation of 2-D diffusion and 1-D convection combined problems
5. Structured grid generation over airfoil section3-D numerical simulation of flow through CDnozzles
6. 3-D numerical simulation of flow development of a subsonic and supersonic jets
7. Numerical simulation of boundary layer development
8. Numerical simulation of subsonic combustion in a ramjet combustor
9. Numerical simulation of transonic flow over airfoils

Minimum of 6 Experiments to be performed by using CFD Software tools

LIST OF EXPERIMENTS IN FEM

1. Grid generation methods and geometry clean up techniques.
2. Static analysis of a uniform bar subject to different loads -1-D element
3. Thermal stresses in a uniform and tapered member – 1-D element
4. Static analysis of trusses / frames under different loads
5. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation ofdiscrete, distributed, and user-defined loads
6. Static analysis of a beam with additional spring support
7. Stress concentration in an infinite plate with a small hole
8. Bending of a plate with different support conditions
9. Stability analysis of a plate under in-plane loads
10. Buckling of solid and thin-walled columns under different end conditions
11. Free vibration analysis of a bar / beam
12. Forced response of a bar / beam under harmonic excitation
13. Heat transfer analysis using 1-D & 2-D elements – conduction and convection
14. Modelling and analysis of a laminated plate
15. Impact analysis of a laminated plate.

Minimum of 6 Experiments to be performed by using FEM Software tools

LABORATORY EQUIPMENTS REQUIREMENTS

1. Desktop computers
2. MS visual C++
3. CFD software

		TOTAL: 60 PERIODS
COURSE OUTCOMES		**Blooms Level**
CO1	To get solution of aerodynamic flows	Analyzing
CO2	To perform stability analysis of structural components	Analyzing
CO3	To define and setup flow problem properly within CFD context, performing solid modelling usingCAD package and producing grids via meshing tool	Analyzing
CO4	To comprehend both flow physics and mathematical properties of governing Navier-Stokesequations and define proper boundary conditions for solution	Analyzing
CO5	To use CFD software to model relevant engineering flow problems	Analyzing

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	1	1	1
CO2	3	2	2	1	1	1
CO3	3	2	3	1	1	1
CO4	3	2	3	1	1	1
CO5	3	2	2	1	1	1

PPAR2PR01	MINI PROJECT WITH SEMINAR	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

Seminar is to be given by the student after the completion of a mini project chosen by the student. Topicsfor the mini projects can be from the aeronautical engineering and allied fields. The mini project can be based on either numerical or analytical solution or design or fully experimental; or a combination of thesetasks.

PPAR1PE01	THEORY OF VIBRATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get insight into the basic aspects of vibration theory.
2	This course presents the principles of dynamics and energy methods pertaining tostructures.
3	This course provides a platform for better understanding of the approximate methods for aerospace structures.
4	To get insight into the dynamic responses of the large systems.
5	To get insight into the basic aspects of aero-elasticity.

UNIT – I	SINGLE DEGREE OF FREEDOM SYSTEMS	9

Simple harmonic motion, definition of terminologies, Newton's Laws, D'Alembert's principle, Energy methods. Free and forced vibrations with and without damping, base excitation, and vibration measuringinstruments.

UNIT – II	MULTI-DEGREES OF FREEDOM SYSTEMS	9

Two degrees of freedom systems, Static and dynamic couplings, Eigen values, Eigen vectors and orthogonality conditions of Eigen vectors, Vibration absorber, Principal coordinates, Principal modes.Hamilton's Principle, Lagrange's equation and its applications.

UNIT – III	VIBRATION OF ELASTIC BODIES	9

Transverse vibrations of strings, Longitudinal, Lateral and Torsional vibrations. Approximate methods forcalculating natural frequencies.

UNIT – IV	EIGEN VALUE PROBLEMS & DYNAMIC RESPONSE OF LARGE SYSTEMS	9

Eigen value extraction methods – Subspace hydration method, Lanczos method – Eigen value reduction method – Dynamic response of large systems – Implicit and explicit methods

UNIT – V	ELEMENTS OF AEROELASTICITY	9

Aeroelastic problems – Collar's triangle of forces – Wing divergence – Aileron control reversal – Flutter.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Able to solve SDOF problems using energy methods	Understanding
CO2	Capable of applying Lagrange's equation in real time vibration problems	Applying
CO3	Able to calculate natural frequency of a system	Applying
CO4	Capable of analysing dynamic response of large systems	Analyzing
CO5	Able to analyse flutter problems	Analyzing

REFERENCE BOOKS:

1	Thomson W.T, Marie Dillon Dahleh, "Theory of Vibrations with Applications", Harlow, EssexPearson 2014.
2	Timoshenko, S. "Vibration Problems in Engineering", John Wiley & Sons, Inc., 2018

3	Meirovitch, L. "Elements of Vibration Analysis", New Delhi, McGraw-Hill Education, 2014
4	F.S. Tse., I.F. Morse and R.T. Hinkle, "Mechanical Vibrations", Prentice-Hall of India, 1985
5	Rao.J.S. and Gupta.K. "Theory and Practice of Mechanical Vibrations", New Delhi, New Age International, 1999

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://nptel.ac.in/courses/112107212
2	https://nptel.ac.in/courses/101104005

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	3	3	-
CO2	3	-	2	3	3	-
CO3	3	-	2	3	3	-
CO4	3	-	2	3	3	-
CO5	3	-	2	3	3	-

PPAR1PE02	ROCKETRY AND SPACE MECHANICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course presents the fundamental aspects of rocket motion along with detailed estimation ofrocket trajectories.
2	This course also imparts knowledge on optimization of multistage rockets.
3	This course provides the basics of space mechanics required for an aeronautical student
4	This course helps students to provide with the basics of orbit transfer of satellites.
5	This course will help students to gain knowledge on various control methods of rockets.

UNIT – I	ORBITAL MECHANICS	9

Description of solar system – Kepler's Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobi's Integral, Libration points – Estimation oforbital and escape velocities.

UNIT – II	SATELLITE DYNAMICS	9

Geosynchronous and geostationary satellites- factors determining life time of satellites – satelliteperturbations – orbit transfer and examples –Hohmann orbits – calculation of orbit parameters– Determination of satellite rectangular coordinates from orbital elements- satellite epiphermis.

UNIT – III	ROCKET MOTION	9

Principle of operation of rocket motor – thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravityturn trajectories– determinations of range and altitude – simple approximations to burnout velocity.

UNIT – IV	ROCKET AERODYNAMICS	9

Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – rocket stability – rocket dispersion – launching problems.

UNIT – V	STAGING AND CONTROL OF ROCKET VEHICLES	9

Need for multi staging of rocket vehicles – multistage vehicle optimization – stage separation dynamicsand separation techniques- aerodynamic and jet control methods of rocket vehicles – SITVC.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To knowledge on the fundamental laws of orbital mechanics with particular emphasis oninterplanetary trajectories	Remembering
CO2	To calculate orbital parameters and perform conceptual trajectory designs for geocentric orinterplanetary missions	Analyzing
CO3	To familiarize themselves with trajectory calculations for planar motion of rockets	Analyzing
CO4	To determine forces and moments acting on airframe of a missile	Analyzing
CO5	To acquire knowledge on the need for staging and stage separation dynamics of rocket vehicles	Analyzing

REFERENCE BOOKS:

1	Cornelisse, JW, "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd., London,2012.
2	Parker, ER, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982
3	Suresh. B N & Sivan. K, "Integrated Design for Space Transportation System", Springer India,2016
4	Sutton, GP, Biblarz, O, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9thEdition, 2017
5	Van de Kamp, "Elements of Astromechanics", Pitman Publishing Co., Ltd., London, 1980

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/101/105/101105029/
2	https://onlinecourses.nptel.ac.in/noc19_ae08/preview

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	-	-	1
CO2	3	-	2	-	3	1
CO3	3	-	3	2	3	1
CO4	3	-	2	-	-	1
CO5	3	-	3	2	2	1

PPAR1PE03	COMPUTATIONAL HEAT TRANSFER	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get insights into the basic aspects of various discretization methods.
2	To provide basic ideas on the types of PDE's and its boundary conditions to arrive at its solution.
3	To impart knowledge on solving conductive, transient conductive and convective problems usingcomputational methods.
4	To solve radiative heat transfer problems using computational methods.
5	To provide a platform for students in developing numerical codes for solving heat transferproblems.

UNIT – I **INTRODUCTION** **9**

Finite Difference Method-Introduction-Taylor's series expansion-Discretization Methods Forward, backward and central differencing scheme for first order and second order Derivatives – Types of partial differential equations-Types of errors-Solution to algebraic equation-Direct Method and Indirect Method-Types of boundary condition-FDM – FEM – FVM

UNIT – II **CONDUCTIVE HEAT TRANSFER** **9**

General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates. Computation (FDM) of One – dimensional steady state heat conduction –with Heat generation- without Heat generation- 2D-heat conduction problem with different boundary conditions- Numerical treatment for extended surfaces- Numerical treatment for 3D- Heat conduction- Numerical treatment to 1D-steady heat conduction using FEM

UNIT – III **TRANSIENT HEAT CONDUCTION** **9**

Introduction to Implicit, explicit Schemes and crank-Nicolson Schemes Computation(FDM) of One– dimensional un-steady heat conduction –with heat Generation-without Heat generation – 2D-transient heat conduction problem with different boundary conditions using Implicit, explicit Schemes-Importance of Courant number- Analysis for I-D,2-D transient heat Conduction problems

UNIT – IV **CONVECTIVE HEAT TRANSFER** **9**

Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-d heat convection- diffusionsteady-unsteady problems- Computation of thermal and Velocity boundary layer flows. Upwind scheme- Stream function-vorticity approach-Creeping flow

UNIT – V **RADIATIVE HEAT TRANSFER** **9**

Radiation fundamentals-Shape factor calculation-Radiosity method- Absorption Method – Montacalro method-Introduction to Finite Volume Method- Numerical treatment of radiation enclosures using finite Volume method. Developing a numerical code for 1D, 2D heat transfer problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES		**Blooms Level**
CO1	Have an Idea about discretization methodologies for solving heat transfer problems	Applying
CO2	Be able to solve 2-D conduction and convection problems	Applying
CO3	Have an ability to develop solutions for transient heat conduction in simple geometries	Evaluating
CO4	Be capable of arriving at numerical solutions for conduction and radiation heat transfer problems	Analyzing
CO5	Have knowledge on developing numerical codes for practical engineering heat transfer problems	Analyzing

REFERENCE BOOKS:	
1	Sachdeva, SC, "Fundamentals of Engineering Heat & Mass Transfer", New age publisher, 4thedition Internationals, 2017.
2	Chung, TJ, "Computational Fluid Dynamics", Cambridge University Press, 2002
3	Holman,JP, "Heat Transfer", McGraw-Hill Book Co, Inc., McGraw-Hill College;10th edition, 2017
4	John D. Anderson, "Computational Fluid Dynamics", McGraw Hill Education, 2017
5	John H. Lienhard, "A Heat Transfer", Text Book, Dover Publications, 5th edition, 2020.
WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:	
1	https://onlinecourses.nptel.ac.in/noc22_me101/preview
2	https://archive.nptel.ac.in/courses/112/105/112105271/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	3	3	-
CO2	3	-	2	3	3	-
CO3	3	-	2	3	3	-
CO4	3	-	2	3	3	-
CO5	3	-	2	3	3	-

AR40

PPAR1PE04	THEORY OF ELASTICITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To learn the basic concepts and equations of elasticity.
2	To provide with the concepts of plain stress and strain related problems.
3	To gain knowledge on equilibrium and stress-strain equations of polar coordinates.
4	To expose to axisymmetric problems.
5	To get insight into the basic concepts of plates and shells.

UNIT – I **BASIC EQUATIONS OF ELASTICITY** **9**

Definition & sign convention for stress and strain – Hooke's law – Relation between elastic constants –Equilibrium and compatibility equations – Analysis of stress, strain and deformation – Stress and strain transformations equations – Cauchy's formula – Principal stress and principal strains in2D & 3D – Octahedral stresses and its significance – Boundary conditions

UNIT – II **APPLIED CONCEPTS** **9**

Plane stress and plane strain problems – Airy stress function – Biharmonic equation – Compatibility equation in terms of stress – Solution of bar and beam problems using the elasticity approach – Torsion ofbars – Determination of stresses, strain and displacements – Warping of cross-sections – Prandtl's stress function approach – St. Venant's method

UNIT – III **POLAR COORDINATES** **9**

Strain-displacement relations in polar coordinates – Equilibrium and stress-strain equations in polar coordinates – Infinite plate with a small central hole – Stress concentration – Bending of a curved beam(Winkler-Bach theory) – Deflection of a thick curved bar – Stresses in straight and curved beams due to thermal loading – Thermal stresses in cylinders and spheres – Stress concentration in bending

UNIT – IV **AXISYMMETRIC PROBLEMS** **9**

Equilibrium and stress-strain equations in cylindrical coordinates – Lame's problem – Thick- walled cylinders subject to internal and external pressure – Application of failure theories – Stresses in compositetubes – Shrink fitting – Stresses due to gravitation – Analysis of a rotating disc of uniform thickness –Discs of variable thickness – Rotating shafts and cylinders

UNIT – V **PLATES AND SHELLS** **9**

Classical plate theory – Assumptions, governing equations and boundary conditions – Navier's method ofsolution – Levy's method of solution – Rectangular and circular plates – Solution techniques – Analysis of a shell – Membrane Theory – Deformation and stresses due to applied loads.

TOTAL: 45 PERIODS

COURSE OUTCOMES		**Blooms Level**
CO1	Have knowledge of basic elasticity relationships and equations.	Remembering
CO2	Know how to carry out stress analysis in 2-D and 3-D	Remembering
CO3	Get exposure on the formulation of constitutive and governing equations for basic problems inCartesian and cylindrical coordinates	Analyzing
CO4	Be able to analyse and solve practical problems in cartesian and cylindrical coordinates	Analyzing
CO5	Be able to determine the stress, strain and displacement field for common axisymmetrical members.	Analyzing

REFERENCE BOOKS:	
1	Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw Hill BookCo., 2nd edition, 2015
2	Flugge, W, "Stresses in Shells", Springer – Verlag, 1990
3	Timoshenko, S.P. and Gere, J.M, "Theory of Elastic Stability", McGraw HillBook Co.2010.
4	Varadan, TK and Bhaskar, K, "Analysis of plates-Theory and problems",NaroshaPublishing Co., 2001
WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:	
1	https://archive.nptel.ac.in/courses/105/105/105105177/
2	https://archive.nptel.ac.in/content/storage2/courses/105108070/module1/lecture1.pdf

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	2	1	1	1
CO2	3	1	2	1	2	1
CO3	1	1	2	1	1	1
CO4	3	1	2	1	3	1
CO5	2	1	2	1	2	1

PPAR1PE05	EXPERIMENTAL AERODYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To learn basics of wind tunnel operation and its associated measurements.
2	To present the concepts of different flow visualization methods.
3	To impart knowledge on flow measurement variables
4	To be familiar with data acquisition methods pertaining to experiments in aerodynamics.
5	To do uncertainty analysis for their experiments

UNIT – I	LOW SPEED TUNNEL	9

Objective of experimental studies, Types of wind tunnels, Low speed tunnel, Energy ratio, Power losses ina wind tunnel – Calibration of subsonic wind tunnels – Speed Setting – Flow Direction – Three-Hole and Five-Hole Yaw Probes – Turbulence – Wind tunnel balance – Water tunnel.

UNIT – II	HIGH SPEED TUNNEL	9

Transonic wind tunnel – Transonic Test Section – Supersonic wind tunnels – Losses in Supersonic Tunnels – Supersonic Wind Tunnel Diffusers– Effects of Second Throat – Runtime calculation – Calculating Air Flow Rates – Calibration of Supersonic Wind Tunnels – Hypersonic wind tunnel andCalibration –Ludwieg Tube – Shock tube and shock tunnels – Gun tunnel – Plasma arc tunnels –Measurement of shock speed.

UNIT – III	FLOW VISUALIZATION TECHNIQUES	9

Strain-displacement relations in polar coordinates – Equilibrium and stress-strain equations in polar coordinates – Infinite plate with a small central hole – Stress concentration – Bending of a curved beam(Winkler-Bach theory) – Deflection of a thick curved bar – Stresses in straight and curved beams due to thermal loading – Thermal stresses in cylinders and spheres – Stress concentration in bending

UNIT – IV	MEASUREMENTS OF PROPERTIES	9

Pressure measurement techniques-Pitot, Static, and Pitot-Static Tubes-Pitot-Static tube characteristics – Pressure Sensitive Paints - Pressure transducers – Velocity measurements – Hot-wire anemometry- Constant current and Constant temperature Hot-Wire anemometer – Hot- film anemometry - Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV)- Temperature measurements – Measurement of heat flux – Foil type heat flux gauge –Transient analysis of foil gauge– Thin film sensors– Slug type heat flux sensor.

UNIT – V	DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS	9

Data acquisition and processing – Signal conditioning – Statistical analysis of experimental data – Regression analysis – Estimation of measurement errors – Uncertainty calculation – Uses of uncertaintyanalysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Have knowledge on measurement of flow properties in wind tunnels and their associatedinstrumentation	Remembering
CO2	Be able to demonstrate and conduct experiments related to subsonic and supersonic flows	Analyzing
CO3	Gain idea on flow visualization of subsonic and supersonic flows	Understanding
CO4	Be familiar with calibration of transducers and other devices used for flow measurement	Analyzing

CO5	Be able to estimate errors and to perform uncertainty analysis of the experimental data.	Applying

REFERENCE BOOKS:

1	Timoshenko, S.P. Winowsky. S., and Kreger, "Theory of Plates and Shells", McGraw Hill BookCo., 2nd edition, 2015
2	Flugge, W, "Stresses in Shells", Springer – Verlag, 1990
3	Timoshenko, S.P. and Gere, J.M, "Theory of Elastic Stability", McGraw HillBook Co.2010.
4	Varadan, TK and Bhaskar, K, "Analysis of plates-Theory and problems",NaroshaPublishing Co., 2001

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/101/105/101105088/
2	https://archive.nptel.ac.in/courses/112/105/112105287/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	-	1	1
CO2	3	3	2	-	3	1
CO3	2	2	2	-	2	1
CO4	3	3	2	-	3	1
CO5	3	2	2	-	3	1

AR44

PPAR1PE06	CONTROL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To introduce the mathematical modelling of systems, open loop and closed loop systems andanalyses in time domain and frequency domain.
2	To impart the knowledge on the concept of stability and various methods to analyse stability in both time and frequency domain
3	To introduce sampled data control system

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 controlsystems, 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 andsinusoidal inputs, Time response of first and second order systems, steady state errors and error constantsof 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		Blooms Level
CO1	Ability to apply mathematical knowledge to model the systems and analyse the frequency domain	Applying
CO2	Ability to check the stability of the both time and frequency domain	Applying
CO3	Ability to solve simple pneumatic, hydraulic and thermal systems, Mechanical and electricalcomponent analogies based problems.	Remembering
CO4	Ability to solve the Block diagram representation of control systems, Reduction of blockdiagrams, Signal flow graph and problems based on it	Analyzing
CO5	Ability to understand the digital control system, Digital Controllers and Digital PID Controllers	Analyzing

REFERENCE BOOKS:

1	OGATO, Modern Control Engineering, Pearson, New Delhi, 2016
2	Azzo, J.J.D. and C.H. Houpis, "Feedback control system analysis and synthesis",McGraw-Hillinternational 3rs Edition, 1998

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/108/106/108106098/

2	https://archive.nptel.ac.in/courses/107/106/107106081/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	-	2	1	1	1
CO2	1	-	2	1	1	1
CO3	1	-	2	1	1	1
CO4	1	-	2	1	1	1
CO5	1	-	2	1	1	1

PPAR2PE07	STRUCTURAL DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course imparts knowledge on the force deflection properties of structures and natural modesof vibration.
2	This course also presents the principles of dynamics and energy methods pertaining to structures.
3	This course will make students to realise the importance of natural modes of vibration.
4	This course will provide in-depth knowledge on natural vibrations of beams and plates.
5	This course also provides a platform for better understanding of the approximate methods foraerospace structures

UNIT – I	FORCE DEFLECTION PROPERTIES OF SYSTEMS	9

Constraints and Generalized coordinates – Virtual work and generalized forces – Force – Deflectioninfluence functions – stiffness and flexibility methods.

UNIT – II	PRINCIPLES OF DYNAMICS	9

Free and forced vibrations of systems with finite degrees of freedom – Response to periodic excitation –Impulse Response Function – Convolution Integral

UNIT – III	NATURAL MODES OF VIBRATION	9

Equations of motion for Multi degree of freedom Systems – Solution of Eigen value problems – Normalcoordinates and orthogonality Conditions- Modal Analysis.

UNIT – IV	ENERGY METHODS	9

Rayleigh's principle – Rayleigh – Ritz method – Coupled natural modes – Effect of rotary inertia andshear on lateral vibrations of beams – Natural vibrations of beams and plates

UNIT – V	APPROXIMATE METHODS	9

Approximate methods of evaluating the Eigen frequencies and eigen vectors by reduced, subspace, Lanczos, Power, Matrix condensation and QR methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Be able to solve the equation of motion of a linear system and use this solution to analyse thevibration behaviour of the system	Applying
CO2	Be capable to relate the results of a modal analysis relate to the vibration of a structure	Applying
CO3	Acquire knowledge on equation of motion of a lumped MDOF mass-spring-damper system	Remembering
CO4	Have knowledge on vibration characteristics of continuous system such as strings, bar, shafts andbeams	Analyzing
CO5	Be able to assess the fundamental frequency of MDOF systems using approximate methods	Analyzing

REFERENCE BOOKS:

1	Hurty, WC and Rubinstein, MF, "Dynamics of Structures", Prentice Hallof India Pvt.Ltd. New Delhi 2017

2	Ramamurthi,V, "Mechanical Vibration Practice and Noise Control", NarosaPublishingHouse Pvt. Ltd, 2008
3	Timoshenko,SP and Young,DH,"Vibration Problems in Engineering", JohnWilley & SonsInc., 1984.
4	Tse.FS, Morse, IE and Hinkle, HT, "Mechanical Vibrations: Theory andApplications",Prentice Hall of India Pvt. Ltd, New Delhi, 2004

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://nptel.ac.in/courses/101105022
2	https://archive.nptel.ac.in/courses/101/104/101104062/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	2	2	2	1
CO2	-	-	2	2	-	1
CO3	-	-	3	2	2	1
CO4	-	-	3	2	-	1
CO5	-	-	2	2	-	1

AR48

PPAR2PE08	HYPERSONIC AERODYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To realise the importance of studying the peculiar hypersonic speed flow characteristics pertainingto flight vehicles.
2	To provide knowledge on various surface inclination methods for hypersonic inviscid flows.
3	To arrive at the approximate solution methods for hypersonic flows.
4	To impart knowledge on hypersonic viscous interactions.
5	To impart knowledge on the effect on aerodynamic heating on hypersonic vehicles

UNIT – I **INTRODUCTION TO HYPERSONIC AERODYNAMICS** **9**

Peculiarities of Hypersonic flows - Thin shock layers – entropy layers – low density and high density flows – hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscidhypersonic flows – velocity vs altitude map for hypersonic vehicles.

UNIT – II **SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS** **9**

Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge tangent cone and shock expansion methods – Calculation of surface flow properties – practical applicationof surface inclination methods – hypersonic independence principle.

UNIT – III **APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS** **9**

Assumptions in approximate methods hypersonic small disturbance equation and theory – Maslen''stheory– blast wave theory – hypersonic equivalence principle- entropy effects - rotational method ofcharacteristics - hypersonic shock wave shapes and correlations.

UNIT – IV **VISCOUS HYPERSONIC FLOW THEORY** **9**

Peculiarities of hypersonic boundary layers - boundary layer equations r – hypersonic boundary layer theory and non-similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layerseffects on aerodynamic heating – heat flux and skin friction estimation.

UNIT – V **VISCOUS INTERACTIONS AND TRANSITION** **9**

Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Parameters affecting hypersonic boundary layer transition - Estimation of hypersonic boundary layertransition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Be able to arrive at the solution for problems involving inviscid and viscous hypersonic flows	Remembering
CO2	Have thorough knowledge on high temperature effects in hypersonic aerodynamics	Remembering
CO3	Be able to arrive at various solution methods to overcome aerodynamic heating problem onhypersonic vehicles	Applying
CO4	To gain ideas on the design issues associated with hypersonic vehicles	Analyzing
CO5	Able to realize the importance and use of the relevant equations for viscous hypersonic flows	Analyzing

REFERENCE BOOKS:

1	Anderson, JD, "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series, 2ndedition, 2016
2	Anderson, JD, "Modern compressible flow: with Historical Perspective", McGraw HillEducation, 3rd edition, 2017
3	William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAAEducation Series, 1994.
4	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Education Series, 1993

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/101/103/101103003/
2	https://archive.nptel.ac.in/content/syllabus_pdf/101103003.pdf

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR2PE09	ADVANCED PROPULSION SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course will cover the basic aspects of thermodynamic cycle analysis of air-breathingpropulsion systems.
2	This course is intended to impart knowledge on advanced air breathing propulsion systems like airaugmented rockets.
3	This course will give the knowledge on the basic aspects of scramjet propulsion system.
4	This course will provide in-depth knowledge about the nozzle performance.
5	This course also presents vast knowledge on the operating principles of nuclear, electric and ionpropulsion.

UNIT – I	THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS	9

Air breathing propulsion systems like Turbojet, turboprop, ducted fan, Ramjet and Air augmented Rockets – Thermodynamic cycles – Pulse propulsion – Combustion process in pulse jet engines – inletcharging process – Subcritical, Critical and Supercritical charging

UNIT – II	RAMJETS AND AIR AUGMENTED ROCKETS	9

Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets –combustor and nozzle design – integral Ram rocket.

UNIT – III	SCRAMJET PROPULSION SYSTEM	9

Fundamental considerations of hypersonic air breathing vehicles – Preliminary concepts in engine airframe integration – calculation of propulsion flow path – flow path integration – Various types of supersonic combustors – fundamental requirements of supersonic combustors – Mixing of fuel jets in supersonic cross flow – performance estimation of supersonic combustors

UNIT – IV	NUCLEAR PROPULSION	9

Nuclear rocket engine design and performance – nuclear rocket reactors – nuclear rocket nozzles – Nuclear rocket engine control – radioisotope propulsion – basic thruster configurations – thrustertechnology – heat source development – nozzle development – nozzle performance of radioisotope propulsion systems.

UNIT – V	ELECTRIC AND ION PROPULSION	9

Basic concepts in electric propulsion – power requirements and rocket efficiency – classification of thrusters – electrostatic thrusters – plasma thruster– Fundamentals of ion propulsion – performanceanalysis – ion rocket engine.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Able to Analyse in detail the thermodynamics cycles of air breathing propulsion systems	Analyzing
CO2	Able to gain idea on the concepts of supersonic combustion for hypersonic vehicles and itsperformance	Remembering
CO3	Able to demonstrate the fundamental requirements of supersonic combustors	Applying
CO4	Capable of estimating performance parameters of nuclear and electrical rockets	Analyzing
CO5	Able to acquire knowledge on the concepts of engine-body installation on hypersonic vehicles	Analyzing

REFERENCE BOOKS:	
1	Anderson, JD, "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series, 2ndedition, 2016
2	Anderson, JD, "Modern compressible flow: with Historical Perspective", McGraw HillEducation, 3rd edition, 2017
3	William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAAEducation Series, 1994.
4	John T. Bertin, Hypersonic Aerothermodynamics, AIAA Education Series, 1993
WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:	
1	https://archive.nptel.ac.in/courses/101/106/101106082/
2	https://www.youtube.com/watch?v=Lv6OuuJbyFo
3	https://nptel.ac.in/courses/112103243

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	2	2	3	1
CO2	3	-	2	-	2	1
CO3	3	-	3	-	2	1
CO4	-	-	3	-	3	1
CO5	2	-	2	-	2	1

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PPAR2PE10	AEROSPACE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get insights into the basic aspects of material science.
2	To provide basic idea on the mechanical behaviour of materials.
3	To impart knowledge on the macro mechanics of composite materials,
4	To gain knowledge on the analysis and manufacturing methods of composite materials.
5	To learn about the sandwich construction

UNIT – I	MATERIAL SCIENCE	9

Crystallography of metals & metallic alloys – Imperfections – Dislocations in Different Crystal Systems –Effect on plasticity – Strengthening Mechanisms Due to Interaction of Dislocations with Interfaces – Other Strengthening Methods – Dislocation Generation Mechanisms

UNIT – II	MECHANICAL BEHAVIOUR	9

Stress-strain curve and mechanical behaviour of materials – linear elasticity and plasticity – failure of ductile and brittle materials – use of failure theories – maximum normal stress and maximum shear stressfailure theories – importance of the octahedral stress failure theory – failure theories based on strain energy – cyclic loading and fatigue of materials – the S-N curve

UNIT – III	METALLIC ALLOYS	9

Metals and alloys used for different aerospace applications – Properties of conventional and advancedaerospace alloys – Effect of alloying elements – Summary of conventional and state- of-the-art manufacturing processes – Types of heat treatment and their effect – other processing parameters –Materials for aerospace application – Design requirements & standards

UNIT – IV	HIGH TEMPERATURE MATERIALS	

Carbon-Carbon Composites and Ceramic Materials For High Temperature Aerospace Application – Manufacturing Technologies & Controlling Parameters – Mechanical and Thermal Properties of These Material Systems – Thermal Protection Material System for a Re-Entry Vehicle – Use of Super alloys –Metal Matrix Composites & Cermets – Properties and Applications – Mechanical and Thermal Fatigue

UNIT – V	SMART MATERIALS	9

Introduction to smart materials-shape memory effects-shape memory alloys-shape memory polymers-electro-rheological fluids-energy harvesting materials-self healing polymers.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Be able to investigate the physical and mechanical behaviour of different materials	Applying
CO2	Have exposure on dislocation theories and their importance	Applying
CO3	Have general knowledge of the properties of different aerospace materials	Applying
CO4	Be able to apply failure theories appropriately	Analyzing
CO5	Be able to select good materials for a specific aerospace application	Analyzing

REFERENCE BOOKS:

1	Adrian Mouritz, "Introduction to Aerospace Materials", Woodhead Publishing, 1st edition, 2012
2	Jones. R M, "Mechanics of Composite Materials", 2nd Edition, CRC Press,Taylor & FrancisGroup, 1998

ARS3

3	Sam Zhang &Dongliang Zhao, "Aerospace Materials Handbook", CRC Press,Taylor & FrancisGroup, 2012.
4	Brain culshaw, smart structures and materials, Artech house, 2000

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/101/106/101106038/
2	https://archive.nptel.ac.in/courses/113/105/113105081/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR2PE11	AIRWORTHINESS AND AIR REGULATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get insight into the basic aspects of aircraft rules.
2	To gain knowledge on the basic concepts of airworthiness.
3	To learn the basic aspects on certification and publication procedures.
4	To impart knowledge on licensing and material selections.
5	To provide with the concepts of case studies and civil aviation requirements

UNIT – I	INTRODUCTION TO AIRCRAFT RULES	9

Airworthiness requirements for civil and military aircraft – CAA, FAA, JAR and ICAO regulations –Defence standards – Military standards and specifications

UNIT – II	BASIC CONCEPTS OF AIRWORTHINESS	9

Privileges and responsibilities of various categories of AME license and approved persons – Knowledgeof mandatory documents like certificate of Registration – Certificate of Airworthiness – Conditions of issue and validity – Export certificate of Airworthiness – Knowledge of Log Book, Journey Log Book,Technical Log Book etc.

UNIT – III	CERTIFICATION AND PUBLICATION PROCEDURES	9

Procedure for development and test flight and Certification – Certificate of Flight release – Certificate ofMaintenance – Approved Certificates – Technical Publications – Aircraft Manual – Flight Manual – Aircraft Schedules – Registration Procedure, Certification, Identification and Marking of Aircraft.

UNIT – IV	LICENSING AND MATERIAL SELECTIONS	9

Modifications – Concessions – Airworthiness directives – Service bulletins – Crew training and their licenses – approved inspection – Approved materials – Identification of approved materials – Bonded andquarantine stores.

UNIT – V	CASE STUDIES AND CIVIL AVIATION REQUIREMENTS	9

Storage of various aeronautical products like rubber goods and various fluids – Accident investigation procedures – Circumstances under which C of A is suspended – ICAO and IATA regulations – Chicago and Warsaw conventions – Familiarization of recent issues of Advisory Circulars – Civil Aviation Requirements Section 2 – Airworthiness.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To realise the importance of aircraft rules	Applying
CO2	To get exposure on the basic concepts of airworthiness	Remembering
CO3	To develop test flight and Certification	Remembering
CO4	To carry out inspections and can identify the approved materials	Remembering
CO5	To analyse the case studies and realise the importance of civil aviation requirements	Analyzing

REFERENCE BOOKS:

1	Civil Airworthiness Requirements (www.dgca.nic.in), 2016
2	Civil Aircraft Airworthiness Information and Procedures (CAP 562)
3	Civil Aviation Requirements Section 2 - Airworthiness.

4	Gran E L and Richard Levenworth, Statistical Quality Control, 7th Edition McGrawHill,1997

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/101/104/101104071/
2	https://archive.nptel.ac.in/courses/101/105/101105084/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	3	3	1
CO2	-	-	2	3	3	1
CO3	-	-	2	3	3	1
CO4	-	-	2	3	3	1
CO5	-	-	2	3	3	1

PPAR2PE12	EXPERIMENTAL METHODS OF STRESS ANALYSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course introduces the basic principles and methods of experimental stress analysis.
2	This course helps to learn the principles and techniques of photoelastic measurements.
3	This course presents the principles and techniques of moire analysis.
4	This course helps to gain knowledge of the principles and a technique of strain gage measurementsis presented.
5	This course also enables the students to learn basic principles of operation of electrical resistancestrain gauges, interferometric techniques, and non-destructive methods

UNIT – I	BASIC CONCEPTS	9

Stresses, Strains and Displacements – Determination of Principal Values of Stresses and Strains in 2-D &3-D – Maximum Shear Stress – Strain Measurement Using Mechanical Extensometers – Principles of Measurements – Basic Characteristics and Requirements of a Measuring System – Sources of error – Statistical Analysis of Experimental Data – Non-Contact Measurement

UNIT – II	ELECTRICAL-RESISTANCE STRAIN GAGES	9

Strain Sensitivity in Metallic Alloys –Gage Construction –Gage Sensitivities and Gage Factor –Performance Characteristics of Foil Strain Gages – Environmental Effects –The Three-Element Rectangular Rosette – Corrections for Transverse Strain Effects – Other Types of Strain Gages –Semiconductor Strain Gages – Grid & Brittle Coating Methods of Strain Analysis.

UNIT – III	STRAIN-GAGE CIRCUITS & INSTRUMENTATION	9

The Potentiometer Circuit and Its Application to Strain Measurement – Variants From The Basic Potentiometer Circuit – Circuit Output – The Wheatstone Bridge Constant Current and Constant VoltageCircuits – Circuit Sensitivity – Calibrating Strain-Gage Circuits –Effects of Lead Wires and Switches –Electrical Noise Reduction – Strain Measurement in Bars, Beams and Shafts.

UNIT – IV	PHOTOELASTIC METHODS OF STRESS ANALYSIS	9

Introduction – Stress-Optic Law – Effects of a Stressed Model in a Plane Polariscope– Effects of a Stressed Model in a Circular Polariscope– Tardy Compensation – Two-Dimensional Photoelastic StressAnalysis – Fringe Multiplication and Fringe Sharpening – Properties of Commonly Employed Photoelastic Materials – Material Calibration – Introduction to Three-Dimensional Photoelasticity and digital photo elasticity.

UNIT – V	NON-DESTRUCTIVE TESTING	9

Different types of NDT Techniques – Acoustic Emission Technique – Ultrasonic – Pulse-Echo – ThroughTransmission – Eddy Current Testing – X-Ray Radiography – Challenges in Non- Destructive Evaluation – Non-Destructive Evaluation in Composites – Concepts of Image Processing Theory.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Knowledge of different methods of strain measurement	Remembering
CO2	Knowledge on electrical resistance strain gauge	Remembering
CO3	An ability to design experiments for strain measurements	Applying
CO4	Acquired knowledge on photo elastic methods of stress analysis	Analyzing
CO5	Exposure to non-destructive testing methods	Analyzing

REFERENCE BOOKS:

1	James W. Dally & William F. Riley, "Experimental Stress Analysis", McGraw-Hill College, 2011
2	Albert S. Kobayashi,"Handbook on Experimental Mechanics", Prentice Hall Publishers,1987
3	James F. Doyle & James W. Phillips, "Manual on Experimental Stress Analysis", 5th Edition,Society for Experimental Mechanics, 1989
4	Sharpe Jr& William N, Springer, "Handbook of Experimental Solid Mechanics",Springer,2008

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://nptel.ac.in/courses/112106068
2	https://archive.nptel.ac.in/courses/108/105/108105064/
3	https://archive.nptel.ac.in/courses/112/106/112106068/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	2	-	1
CO2	-	-	2	2	-	1
CO3	2	-	3	-	-	1
CO4	-	-	3	2	-	1
CO5	-	-	2	3	-	1

PPAR2PE13	AERO ELASTICITY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course provides the basic knowledge on aero elastic phenomena and its impact on aircraftdesign.
2	This course will make students to illustrate the Aeroelastic phenomena using simplified aerodynamic and structural models
3	This course provides insight into both static and dynamic Aeroelastic phenomena and possibleprevention methods.
4	This course imparts knowledge on the flutter phenomena in detail.
5	This course provides the basic knowledge on prevention and control of Aeroelastic instabilities

UNIT – I **AEROELASTIC PHENOMENA** **9**

Stability versus response problems – introduction to Aeroelasticity and aeroelastic phenomena – Examples of aeroelastic phenomena – Galloping of transmission lines – Flow induced vibrations of tallslender structures – Instability of suspension bridges – Fluid structure interaction – The aero-elastic triangle of forces – Prevention of aeroelastic instabilities

UNIT – II **MODELLING OF AEROELASTIC PHENOMENA** **9**

Influence and stiffness co-efficients – illustration of aeroelastic phenomena using simplified aerodynamicand structural models – different subsonic and supersonic aerodynamic models for aeroelastic analysis – modelling techniques – aeroelastic models in state-space format Flexure – torsional oscillations of beams– Governing differential equation of motion and its solution.

UNIT – III **STATIC AEROELASTIC PHENOMENA** **9**

Simple two dimensional idealisation – Strip theory – Exact solutions for simple rectangular wings –'Semi-rigid' assumption and approximate solutions – Successive approximation method – Numerical approximations using matrix equations – Divergence of 2-D airfoil and Straight Wing – Aileron efficiency& reversal – Control Effectiveness – Wing deformations of swept wings.

UNIT – IV **FLUTTER CALCULATIONS** **9**

Flutter analysis – Two dimensional thin airfoils in steady incompressible flow –Quasi-steady aerodynamicderivatives – Galerkin method for critical flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – FlutterCalculation – U-g Method – P-k Method – Exact Treatment of Bending –Torsion Flutter of a Uniform Wing – Flutter Analysis by Assumed Mode Method

UNIT – V **PREVENTION AND CONTROL** **9**

Stiffness criteria – dynamic mass balancing – dimensional similarity – effect of elastic deformation on static longitudinal stability – introduction to aeroelastic control – aeroelastic aspects in the design of aircraft – Panel flutter and its control – Prevention of tail buffeting – Aeroelastic instabilities in helicopterand engine blades and prevention methods

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Have knowledge of the role of Aeroelasticity in aircraft design	Remembering
CO2	Interpret the use of semi-rigid body assumptions and numerical methods in airplane design	Analyzing
CO3	Arrive at the solutions for steady state aeroelastic problem	Remembering
CO4	Be knowledge with the concept of flutter analysis of aircraft wings.	Analyzing
CO5	Have knowledge on practical examples of aeroelastic problems.	Analyzing

REFERENCE BOOKS:

1	Bisplinghoff.RL, Ashley, H and Halfmann, RL, "Aeroelasticity", 2nd Edition, Addison WesleyPublishing Co., Inc., 2016
2	Blevins, RD,"Flow Induced Vibrations", Krieger Pub Co., 2001
3	Broadbent, EG,"Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986
4	Fung, YC,"An Introduction to the Theory of Aeroelasticity", John Wiley & SonsInc., New York,2008

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://nptel.ac.in/courses/101104005
2	https://archive.nptel.ac.in/content/storage2/courses/101105022/m1l1.pdf
3	https://www.iitk.ac.in/aero/courses
4	https://www.youtube.com/watch?v=O8ZGbmLKv8I

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	-	-	1
CO2	3	-	2	3	2	1
CO3	3	-	2	-	2	1
CO4	-	-	2	-	-	1
CO5	-	-	2	3	-	1

PPAR2PE14	THEORY OF BOUNDARY LAYERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course imparts knowledge to students on growth of boundary layer and its effect on theaerodynamic design of airframe of flight vehicles.
2	This course will introduce them the solution methods for boundary layer problems.
3	This course enables the students to understand the importance of viscosity and boundary layer influid flow
4	This course also introduces the theory behind laminar and turbulent boundary layers.
5	This course will make students to learn the concepts of boundary layer transition and separation

UNIT – I	THEORY 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-dimensionalising the basic equations and boundary conditions, vorticity considerations, creeping flow, boundary layer flow.

UNIT – II	INCOMPRESSIBLE VISCOUS FLOWS AND BOUNDARY LAYER	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 – III	LAMINAR BOUNDARY LAYER THEORY	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, Integral equation of Boundary layer – Pohlhausen method – Thermal boundary layer calculations.

UNIT – IV	THEORY OF 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, mixinglength , Turbulence modelling

UNIT – V	BOUNDARY LAYER TRANSITION AND SEPARATION	9

Boundary layer control in laminar flow-Methods of Boundary layer control: Motion of the solid wall- Acceleration of the boundary layer-Suction- Injection of different gas-Prevention of transition- Cooling ofthe wall-Boundary layer suction-Injection of a different gas.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To apply proper governing equations for various types of viscous flows in engineering applications	Applying
CO2	To obtain solutions for various viscous flow problems in engineering	Analyzing
CO3	To estimate skin friction over solid surfaces, over which laminar boundary layer persists	Remembering
CO4	To arrive at the solutions for turbulent boundary layer and the resulting drag	Analyzing
CO5	To gain insights on the techniques for boundary layer control	Analyzing

REFERENCE BOOKS:

1	White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York, 2018
2	Schlicting, H., Boundary Layer Theory, McGraw-Hill, New York, 1979
3	Reynolds, A, J., Turbulent Flows Engineering, John Wiley and Sons, 1980.

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://www.youtube.com/watch?v=Myk9gX8-CeI
2	https://archive.nptel.ac.in/courses/112/103/112103302/
3	https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-me45/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	2	3	1
CO2	-	-	2	3	3	1
CO3	-	-	2	3	3	1
CO4	-	-	2	2	3	1
CO5	-	-	2	1	3	1

PPAR2PE15	COMBUSTION IN JET AND ROCKET ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course provides the basic principles of combustion, types of flames and also familiarizes the combustion process in gas turbine, ramjet, scram jet and rocket engines.
2	This course explains the concept of thermo chemistry, enthalpy, adiabatic flame temperature, combustion products and their application to combustion related problems.
3	This course presents the concept of chemical rates of reaction, collision theory and Arrhenius equation for analysing the different types of reactions.
4	This course gives an idea to compare the properties and characteristics of different type of flames and apply the same to combustion phenomenon in rocket motors and its exhaust.
5	This course also imparts knowledge to interpret the various combustion processes that take place in chemical rockets.

UNIT – I	THERMODYNAMICS OF COMBUSTION	9

Stoichiometry – absolute enthalpy- enthalpy of formation- enthalpy of combustion- laws of Thermo chemistry- pressure and temperature effect on enthalpy of formation, adiabatic flame temperature, chemical and equilibrium products of combustion

UNIT – II	PHYSICS AND CHEMISTRY OF COMBUSTION	9

Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow. BasicReaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics

UNIT – III	PREMIXED AND DIFFUSED FLAMES	9

One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flamestabilizations, Turbulent Premixed flame. Gaseous and diffusion flame – Examples -. Differences between premixed flame and diffusion.

UNIT – IV	COMBUSTION IN GAS TURBINE, RAMJET AND SCRAMJET	9

Combustion in gas turbine chambers, recirculation, combustion efficiency, flame holders, subsonic combustion in ramjet, supersonic combustion in scramjet. Subsonic and supersonic combustion controlledby diffusion mixing and heat convection – peculiarities of supersonic combustion

UNIT – V	COMBUSTION IN CHEMICAL ROCKET	9

Combustion in liquid propellant rockets. Combustion of solid propellants- application of laminar flame theory to the burning of homogeneous propellants, Combustion in hybrid rockets- Combustion instabilityin rockets

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Apply the basic concept of thermo chemistry to combustion related problems	Applying
CO2	Demonstrate the concept of chemical kinetics in combustion reactions	Remembering
CO3	Differentiate between deflagration and detonation process and interpret the concept for computationand analysis of the transition phenomenon	Applying
CO4	Demonstrate the peculiarities of supersonic combustion.	Analyzing
CO5	Evaluate the combustion processes taking place in different types of chemical rockets	Analyzing

REFERENCE BOOKS:

1	Kuo, KK, "Principles of Combustion", John Wiley and Sons, 2015
2	Warren C. Strahle, "An Introduction to Combustion", Taylor & Francis, 1993

3	Mukunda, HS, "Understanding Combustion", 2nd edition, Orient Blackswan, 2009
4	Mishra, DP, "Fundamentals of Combustion", Prentice Hall of India, New Delhi, 2008

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:	
1	https://archive.nptel.ac.in/courses/112/106/112106290/
2	https://archive.nptel.ac.in/noc/courses/noc22/SEM1/noc22-me33/
3	https://onlinecourses.nptel.ac.in/noc22_me33/preview
4	https://archive.nptel.ac.in/courses/101/104/101104078/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	2	3	2	1
CO2	-	-	2	2	3	1
CO3	2	-	3	2	3	1
CO4	-	-	3	3	2	1
CO5	2	-	2	3	3	1

AR64

PPAR2PE16	GAS DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To gain insights into the steady one-dimensional fluid flow, its model and tool to solve the fluidflow problems.
2	To acquire knowledge about the normal shock waves.
3	To acquire knowledge about the oblique shock and expansion waves.
4	To gain knowledge about the basic measurements involved in compressible flows.
5	To acquire basic knowledge about the rarefied and high temperature gas dynamics

UNIT – I **STEADY ONE-DIMENSIONAL FLOW** **9**

Thermodynamics of Fluid Flow – First Law of Thermodynamics - The Second Law of Thermodynamics -Thermal and Calorical Properties – Perfect Gas - Wave Propagation – Velocity of Sound - Subsonic and Supersonic Flows – Fundamental Equations - Discharge from a Reservoir – Stream tube Area-Velocity Relation - De Laval Nozzle – Supersonic Flow Generation–Diffusers - Dynamic Head Measurement in Compressible Flow - Pressure Coefficient

UNIT – II **NORMAL SHOCK WAVES** **9**

Introduction – Equations of Motion for a Normal Shock Wave - The Normal Shock Relations for a PerfectGas - Change of Stagnation or Total Pressure across the Shock- Hugoniot Equation - The Propagating Shock Wave - Reflected Shock Wave - Centered Expansion Wave - Shock Tube.

UNIT – III **OBLIQUE SHOCK AND EXPANSION WAVES** **9**

Introduction – Oblique Shock Relations - Relation between θ and β- Shock Polar – Supersonic Flow overa Wedge - Weak Oblique Shocks – Supersonic Compression - Supersonic Expansion by Turning - The Prandtl-Meyer Expansion - Simple and Non-simple Regions.

UNIT – IV **MEASUREMENTS IN COMPRESSIBLE FLOW** **9**

Introduction - Pressure Measurements – Temperature Measurements - Velocity and Direction - DensityProblems - Compressible Flow Visualization - High-Speed Wind Tunnels - Instrumentation and Calibration of Wind Tunnels.

UNIT – V **INTRODUCTION TO RAREFIED AND HIGH TEMPERATURE GAS DYNAMICS** **9**

Knudsen Number - Slip Flow Transition and Free Molecule Flow - Importance of High- TemperatureFlows - Nature of High-Temperature Flows

TOTAL: 45 PERIODS

COURSE OUTCOMES		**Blooms Level**
CO1	Be able to solve the steady one dimensional compressible fluid flow problems	Remembering
CO2	Be provided with the knowledge on thermodynamic state of the gas behind normal shock waves	Remembering
CO3	Be provided with the knowledge on thermodynamic state of the gas behind oblique shock wavesand expansion waves	Remembering
CO4	Be provided with the adequate knowledge on compressible flow measurements.	Analyzing
CO5	Be provided with the basic knowledge on rarefied and high temperature gas dynamics	Analyzing

REFERENCE BOOKS:

1	Rathakrishnan. E., Gas Dynamics, Prentice Hall of India, 7th edition, 2020.
2	J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill Education, 6th edition,2017

3	Shapiro, AH, "Dynamics & Thermodynamics of Compressible Fluid Flow", RonaldPress, 1982
4	Houghton, EL and Caruthers, NB," Aerodynamics for Engineering Students",Butterworth-Heinemann Series, 7th Edition 2017

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/101/106/101106044/
2	https://nptel.ac.in/courses/101106044
3	https://nptel.ac.in/courses/101108086

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	2	-	3	2	2	2
CO2	2	-	3	2	2	2
CO3	2	-	3	2	2	2
CO4	2	-	3	2	2	2
CO5	-	-	3	2	2	2

PPAR2PE17	FATIGUE AND FRACTURE MECHANICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To learn the fundamentals aspects of fatigue & fracture mechanics.
2	To gain knowledge on the statistical aspects of fatigue behaviour of materials.
3	To get insights into the physical aspects of fatigue.
4	To evaluate the strength of the cracked bodies.
5	To provide knowledge on fatigue design and testing of aerospace structures.

UNIT – I **BASIC CONCEPTS & OVERVIEW** **9**

Historical Perspective – Case Studies – Review of Material Behaviour – Linear & Non-Linear Response –Temperature and Strain Rate Effect – Strain Hardening – Different Mechanisms of Failure – Typical Defects & Elements of Dislocation Theories – Atomic View of Fracture – Fractographic Examination of Failure Surfaces of Different Materials – Overview of Design Approach – Safe Life Design

UNIT – II **FATIGUE OF STRUCTURES** **9**

S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Stress concentration factors – Notched S-N curves – Lowcycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Load History Analysis – Cycle counting techniques–Cumulative damage theory

UNIT – III **PHYSICAL ASPECTS OF FATIGUE** **9**

Fracture mechanism in metals - Phase in fatigue life – Crack source – Cleavage initiation – Crack growth – Ductile-brittle transition – Final fracture – Dislocations – Fatigue fracture surface of inter and intra-granular fracture – Environmental effects – Terminology and classification – Corrosion principles – Stresscorrosion cracking – Hydrogen embrittlement – Influencing parameters on crack behaviour

UNIT – IV **LINEAR ELASTIC FRACTURE MECHANICS** **9**

Stress analysis and strength of a cracked body – Stress concentration – potential energy and surface energy – Energy release rate – Griffith's theory – Irwin extension of Griffith's theory to ductile materials– Plastic zone shape – Effect of thickness on fracture toughness – Stress intensity factors for typicalgeometries – Instability of the R-curve – K-controlled fracture – Plane strain fracture toughness – Mixed mode – Interaction of cracks – Limitations of the linear elastic fracture theory

UNIT – V **FRACTURE TOUGHNESS TESTING** **9**

General considerations for metallic specimens – Specimen configuration – Stress intensity factors – Pre- cracking – Grooving – ASTM E-399 and similar standards – K-R curve – J-testing on metals – Determination of crack parameters – CTOD testing – Testing of metals in the ductile- brittle transition region – Quantitative toughness tests – Charpy&Izod tests –- Mathematical modelling concepts

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To identify and describe the basic fracture and fatigue mechanisms and apply that knowledge tofailure analysis	Analyzing
CO2	To correctly apply linear elastic fracture to predict material failure	Analyzing
CO3	To predict lifetimes for fatigue and environmentally assisted cracking	Remembering
CO4	To demonstrate fatigue design and testing of structures	Remembering
CO5	To realise the importance of composite materials in Aerospace structures	Analyzing

REFERENCE BOOKS:

1	Barrois, W &Ripley, L, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 2013
2	Brock,D, "Elementary Engineering Fracture Mechanics", Noordhoff International Publishing Co., London, 1994
3	Knott,JF, "Fundamentals of Fracture Mechanics", Butterworth & Co. Ltd., London,1983.
4	Sih,CG, "Mechanics of Fracture, Vol.1", Sijthoff and Noordhoff International Publishing Co., Netherland, 1989

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1	https://archive.nptel.ac.in/courses/113/105/113105106/
2	https://onlinecourses.nptel.ac.in/noc22_mm42/preview
3	https://archive.nptel.ac.in/courses/112/106/112106065/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	2	2	1	2	2	1
CO3	3	2	1	3	3	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1

PPAR3PE18	Vibration Isolation and Control	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get insight into the basic aspects of vibration theory.
2	To get in-depth knowledge on different types of isolators and its effectiveness.
3	To provide the basic knowledge on dynamic vibration absorber.
4	To realize the importance of materials selection for appropriate applications.
5	To get knowledge on the principles of active vibration control.

UNIT – I **BASIC VIBRATION THEORY** **9**

Free Vibration Theory – Determination of Natural Frequency of a Single Degree Of Freedom –System– Response of a Damped Single Degree of Freedom System – Role of Damping – Forced Vibrations of Discrete Systems – Continuous Systems – Vibrations of Beams and Shafts – Idealization of a Real System Into a Discrete Model – Resonance – An Overview of the Different Methods of Vibration Control

UNIT – II **VIBRATION ISOLATION** **9**

Transmissibility – Numerical Examples – Necessity of Vibration Isolation – Vibration Reduction at Source – System Redesign – Different Types of Isolators & Their Effectiveness – Pneumatic Suspension – Excitation Reduction at Source and Factors Affecting Vibration Level – Source Classification – Control of Flow Induced & Self-Excited Systems

UNIT – III **DYNAMIC VIBRATION ABSORBER** **9**

Dynamic Vibration Neutralizers – Self-tuned Pendulum Neutralizer - Optimum Design of Damped Absorbers – Absorber with ideal spring and viscous dashpot – Gyroscopic vibration absorbers – Impact Absorbers – Absorbers attached to continuous systems – Field Balancing of Rotors – Resonance: Detuning and Decoupling – Remedial Measures

UNIT – IV **SELECTION OF MATERIALS** **9**

Dynamic Properties of Viscoelastic Material – Selection of Materials – Damping-Stress Relationship – Selection Criteria for Linear Hysteretic Material – Design for enhanced material damping – Linear Viscoelastic Model – Constrained Layer Damping – Relaxation – Frequency and Temperature Dependence of the Complex Modulus – Overview and Role of Smart Materials

UNIT – V **PRINCIPLES OF ACTIVE VIBRATION CONTROL** **9**

Conceptual Understanding – Shape Memory Actuators for Vibration Control – Shape Memory Materials – Tuned Vibration Absorbers using SMA – Basics of Electro-and Magneto-Rheological Fluids – Active Vibration Isolation using ERF and MRF – Methods of Active Vibration Control Using Piezoelectric Materials – Derivation of Governing Equations – Response of the Structure.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To realise the importance of vibration theory & its practical applications	Evaluating
CO2	To work out response calculations	Evaluating
CO3	To analyse and compare the different methods of vibration control	Applying

CO4	To exposure on vibration control using smart materials	Analyzing
CO5	To design a vibration control unit	Analyzing

REFERENCE BOOKS:

1	Malcolm J. Crocker, "Handbook of Noise and Vibration Control", Wiley; 1st edition, 2007.
2	Mallik, AK, "Principles of Vibration Control",Affiliated East-West Press, India, 1990.
3	Mead,DJ, "Passive Vibration Control", Wiley, 1st edition, 1999.
4	Preumont,A"Vibration Control of Active Structures", Springer Netherlands, 3rd edition, 2011.

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1	http://www.digimat.in/nptel/courses/video/112107087/L10.html
2	https://archive.nptel.ac.in/courses/112/104/112104211/
3	https://www.youtube.com/watch?v=bcuS3DW88a4
4	https://www.youtube.com/watch?v=vLaFAKnaRJU

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE19	Non-Destructive Evaluation	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To impart knowledge on the fundamentals of non-destructive testing methods and techniques, aircraft inspection methodology using NDT methods
2	To get insights into the basic aspects of electron microscopy.
3	To learn modern NDT techniques like acoustic emission, ultrasonic and thermographic testing methods
4	To inspect the aircraft structures using NDT techniques
5	To get basic knowledge on the structural health monitoring of aerospace structures

UNIT – I	INTRODUCTION	9

Need for non-destructive evaluation (NDT) – Applications – Structural inspection – Structural deterioration due to corrosion and fatigue – Crack growth – Fabrication defects – Overloading – Detailed visual inspection – Aircraft wing and fuselage inspection using various NDT techniques – Overview and relative comparison of NDT methods – Jet engine inspection – Critical locations –

UNIT – II	ELECTRON MICROSCOPY	9

Fundamentals of optics – Optical microscope and its instrumental details – Variants in the optical microscopes and image formation – Polarization light effect – Sample preparation and applications of optical microscopes – Introduction to Scanning electron microscopy (SEM) – Instrumental details and image formation of SEM – Introduction to transmission electron microscopy (TEM) – Imaging techniques and spectroscopy – Sample preparation for SEM and TEM

UNIT – III	ACOUSTIC EMISSION AND ULTRASONICS	9

Sources of acoustic emission – Physical principals involving acoustic emission and ultrasonics – Configuration of ultrasonic sensors – Phased array ultrasonics – Instrument parts and features for acoustic emission and ultrasonics – Defect characterization – Inspection of cracks and other flaws in metals and composites – Interpretation of data – Image processing – Concepts and application

UNIT – IV	AIRCRAFT INSPECTION	9

Inspection Levels – General Visual Inspection – During pre, or post flight – Detailed Visual Inspection (DET) – Periodic inspection – Special Detailed Inspection (SDET) – Uses of NDT Methods – Jet Engine Inspection – Engine overhaul – Fluorescent penetrate inspection – Airframe Loading – Fuselage Inspection – Critical Locations – Comparison of different methods of NDT – Visual – Radiography – Eddy Current Testing – Liquid Penetrant Testing – Remote Testing - Landing Gear Inspection

UNIT – V	STRUCTURAL HEALTH MONITORING	9

An Overview of Structural Health Monitoring – Structural Health Monitoring and Role of Smart Materials – Structural Health Monitoring versus Non-Destructive Evaluation – A Broad Overview of Smart Materials Applications – Notable Applications of SHM in Aerospace Engineering – Structural health monitoring of composites – Repair investigation using SHM – Current limits and future trends.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To realize the importance of various NDT techniques	Evaluating
CO2	To identify suitable NDT technique for a particular application.	Evaluating

CO3	To demonstrate the physical principles involved in acoustic emission and ultrasonics.	Applying
CO4	To have knowledge on the physical principles involved in the various other techniques of NDT.	Analyzing
CO5	To realise the state-of-the-art in NDT testing and structural health monitoring.	Analyzing

REFERENCE BOOKS:

1	Cullity, BD & Stock, SR, "Elements of X-ray diffraction", Prentice Hall, Inc. USA, 2001.
2	Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, "Structural Health Monitoring", Wiley- ISTE, 2006.
3	Douglas E Adams, "Health Monitoring of Structural Materials and Components-Methods with Applications", John Wiley and Sons, 2007
4	Douglas B. Murphy, "Fundamentals of light microscopy and electronic imaging", Wiley-Liss, Inc. USA, 2001.
5	Richard Brundle. C, Charles A. Evans, Jr., Shaun Wilson, "Encyclopedia of Materials Characterization, Surfaces, Interfaces, Thin Films", Butterworth-Heinemann, Boston, USA, 1992.

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1	https://archive.nptel.ac.in/courses/113/106/113106070/
2	https://en.wikipedia.org/wiki/Nondestructive_testing
3	https://dolphitech.com/?gad_source=2&gclid=EAIaIQobChMIxre8lP3ZhAMVO9sWBR3rQQoUEAAYASABEgJFe_D_BwE
4	https://onlinecourses.nptel.ac.in/noc20_mm07/preview

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

AR-22

PPAR3PE20	Component Design of Aircraft Engines	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course provides the fundamental principles of fluid mechanics and thermodynamics on jet engine design.
2	This course brings out the differences in the design of various types of gas turbine engines.
3	This course imparts knowledge on the effect of inlet design on aerodynamic and propulsive aspects of aircrafts.
4	This course also addresses the problems associated with the design of combustion chambers.
5	This course deals with the practical difficulties in the matching of compressor and turbine

UNIT – I	DESIGN FUNDAMENTALS OF GAS TURBINE ENGINE	9

Design Process - Constraint Analysis - Preliminary estimates - Aircraft weight and fuel consumption data- Mission analysis – Performance cycle analysis – Engine installation drag and sizing – Current challenges in gas turbine technology.

UNIT – II	INLET DESIGN	9

Elements of an Inlet - Engine Integration – Subsonic inlet - Engine Operational Requirements - Supersonic Inlet - Engine Operational Requirements - Engine Impact on Inlet Design – Inlet Impact on Engine Design- Validation of Inlet-Engine System

UNIT – III	DESIGN OF ROTATING COMPONENTS	9

Fan and Compressor Aerodynamics - Diffusion factor - Aerofoil geometry - Flow path dimensions - Radial variation - Turbine Aerodynamics - Constant axial velocity – adiabatic - selected Mach number - Mean line stage Design - tage pressure ratio - Airfoil geometry - Radial variation - Turbine cooling - Engine life - Design Examples

UNIT – IV	COMBUSTION CHAMBER DESIGN	9

Combustion system components- Chemical reactor theory - Combustor Stability map-Stirring and mixing-Total pressure loss-Fuels-Ignition-Combustion Systems of Main 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-Example Design calculation: Design of Afterburners-Design parameters- Components-Diffuser-Fuel injection-Ignition-Flame stabilization-Flame spread and after burner length-Example design calculations.

UNIT – V	EXHAUST NOZZLE DESIGN	9

Different types of Nozzles – design of nozzles - Jet control methods for reduction of infrared signature on military aircrafts - Simple design problem - One dimensional nozzle flow.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To successfully design a gas turbine engine for given requirements.	Evaluating
CO2	To have thorough knowledge with the operational behavior of the major components of gas turbine engines	Evaluating

CO3	To identify the factors those limit the performance of the components of gas turbine engines.	Applying
CO4	To find solutions for the compressor and turbine matching in gas turbine engines.	Analyzing
CO5	To overcome the problems associated with inlet on aircrafts	Analyzing

REFERENCE BOOKS:

1	Cumpsty,N, "Jet Propulsion: A Simple Guide to the Aerodynamics and Thermodynamics Design and Performance of Jet Engines", Cambridge University Press, 2nd edition, 2003
2	Mattingly.JD,Heiser,WH and Pratt,DT,"Aircraft Engine Design", 2nd Edition, AIAA Education Series, 2002.
3	Oates. GC,"Aircraft Propulsion Systems Technology and Design", AIAA Education Series, 1989.
4	Saravanamuttoo, HIH andRogers,GFC,"Gas Turbine Technology", Pearson Education Canada, 6th edition, 2008
5	Treager,IE,"Aircraft Gas Turbine Engine Technology", 3rd edition, Glencoe McGraw-Hill, Inc.1995.

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1	https://archive.nptel.ac.in/courses/101/101/101101002/
2	https://en.wikipedia.org/wiki/Aircraft_engine
3	https://www.youtube.com/watch?v=L24Wf0VlTE0
4	https://www.youtube.com/watch?v=KjiUUJdPGX0

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE21	Aircraft Systems Engineering	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To provide exposure to basic concepts of Aircraft product system engineering and design
2	To provide exposure to different fault and failure analysis methods in aircraft systems
3	To provide exposure on systems engineering process, System Architecture and integration
4	To provide exposure on the importance of Maintainability, reliability and availability of the product.
5	To provide exposure importance of formal planning and documentation in systems engineering.

UNIT – I	INTRODUCTION TO SYSTEMS ENGINEERING	9

Overview of Systems Engineering- Systems Engineering Concept Map-Systems Definition-The seven steps Systems Engineering-Conceptual System Design- System Engineering Process-Requirements and Management-Trade Studies-Integrated Product And Process Development

UNIT – II	THE AIRCRAFT SYSTEMS AND DESIGN	9

Introduction- Everyday Examples of Systems- Aircraft Systems –Generic Systems-Product Life Cycle- Different Phases-Whole Life Cycle Tasks- Systems Analysis-Design Drivers in the Project, Product, Operating Environment- Interfaces with the Subsystems-Mission analysis

UNIT – III	SYSTEM ARCHITECTURE SAND INTEGRATION	9

Introduction- Systems Architectures –Modeling and Trade-Offs Evolution of Avionics Architectures- Systems Integration Definition-Examples of Systems Integration-Integration Skills-Management of Systems Integration

UNIT – IV	PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL	9

Stakeholders- Communications- Criticism- Configuration Control Process-Portrayal of a System-Varying Systems Configurations- Compatibility-Factors Affecting Compatibility–Systems Evolution. Considerations and Integration of Aircraft Systems- Risk Management

UNIT – V	SYSTEMS RELIABILITYAND MAINTAINABILITY	9

Systems and Components-Analysis- Influence, Economics, Design for Reliability-Fault and Failure Analysis-System Life Cycle cost-Case Study-Maintenance Types-Program-Planning and Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Describe the importance of systems engineering process in product development	Evaluating

CO2	Categorize different aircraft systems and will be able to differentiate the avionics architectures	Evaluating
CO3	Outline the different stages of product development and factors influencing in each stage	Applying
CO4	Analyze the different alternatives during design process	Analyzing
CO5	Plan, organize and document the task related to product design, development and testing.	Analyzing

REFERENCE BOOKS:

1	Andrew P.Sage& James E.Armstrong, "Introduction to Systems Engineering", 1st edition,2000
2	Erik Aslaksen& Rod Belcher, "Systems Engineering", Prentice Hall, 1992
3	Ian Moir&Allan Seabridge, "Design and Development of Aircraft Systems", Wiley, 2nd edition,2012.
4	Ian Moir& Allan Seabridge, "Aircraft Systems Mechanical, electrical, and avionics subsystems integration", John Wiley &Sons Ltd, 2011
5	Peter. Sydenham, "Systems Approach to Engineering Design",Artechhouse,Inc,London,2003.

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1	https://onlinecourses.nptel.ac.in/noc24_ae05/preview
2	https://en.wikipedia.org/wiki/Systems_engineering
3	https://www.youtube.com/watch?v=NZLbTuBDhJg
4	https://nptel.ac.in/courses/101104071

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE22	Aircraft Design	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get in-depth knowledge about the preliminary concepts of aircraft design
2	To provide with the basic knowledge on various aircraft loads
3	To learn the design of aircraft wing
4	To get exposed to different kinds of landing gear and its design
5	To provide with the basic knowledge on integration of wing, fuselage, empennage and power plant.

UNIT – I	PRELIMINARY CONCEPTS	9

Aircraft Design Requirements - Specifications - Role of user - Aerodynamic and Structural considerations - Importance of weight fractions - Airworthiness requirements and standards Classification of airplanes - Special features of an airplane- Airplane performance aspects - Range and endurance - Take-off and landing - Climbing performance - Engine Performance

UNIT – II	AIRCRAFT LOADS	9

Ground loads - Flight Loads - Symmetrical loads in flight - Basic flight loading conditions – Load factor calculation during a manouever - Velocity - Load factor diagram - Gust load and its estimation - Structural limits - Airplane weight estimation based on type of airplane - Trends in wing loading - Weight-estimation based on mission requirements - iterative approach -Span wise load distribution - Wing Loading.

UNIT – III	WING DESIGN	9

Selection of airfoil selection - Influencing factors - Planform shapes of an airplane wing - Stalling, takeoff and landing considerations - Wing drag estimation - High lift devices - Supercritical Airfoils - Cockpit and aircraft passenger cabin layout for different aircraft - types of associated structure - structural layout - features of light airplanes using advanced composite materials – Structural design aspects - Bending moment and shear force diagram for wing and fuselage – Design principles of all metal stressed skin construction for civil and military applications.

UNIT – IV	LANDING GEAR	9

Different kinds of landing gears and associated arrangement for civil and military airplanes - Preliminary calculations for locating main and nose landing gears - Integration of Structure and Power Plant - Estimation of Horizontal and Vertical tail volume ratios - Choice of power plant and various options of locations - Considerations of appropriate air-intakes- Power Plant Loading.

UNIT – V	INTEGRATION OF WING, FUSELAGE, EMPENNAGE AND POWER PLANT	9

Estimation of center of gravity - Introduction to advanced concepts - Aircraft Stability – Relaxed static stability - Controlled configured vehicles - V/STOL aircraft & rotary wing vehicles – Design and layout of flying controls and engine controls - Design of a wing-fuselage joint.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Have overall knowledge of preliminary aircraft design	Evaluating

CO2	Have basic knowledge of aircraft rules and airworthiness requirements imposed by governing bodies	Evaluating
CO3	Be able to calculate and estimate aircraft loads under different loading conditions	Applying
CO4	Be able to configure an aircraft wing based on aerodynamic considerations	Analyzing
CO5	Be exposed the role of aircraft stability in the aircraft design process	Analyzing

REFERENCE BOOKS:

1	Daniel P Raymer, "Aircraft Design: A conceptual approach", AIAA Educational Series, 5th edition 2012
2	DarrolStinton ,"The Design of Airplane", Wiley publishers,, 2nd edition, 2001
3	John D Anderson, "Airplane Performance and Design", McGraw Hill, 1st edition,1999
4	Nicholai, LM, "Fundamentals of airplane Design", Univ. of Dayton DHIO, 1975.
5	Torenbeek, Egbert, "Synthesis of Subsonic Airplane Design", Springer publishers, 1982.

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1	https://onlinecourses.nptel.ac.in/noc21_ae04/preview
2	https://archive.nptel.ac.in/courses/101/104/101104069/
3	https://en.wikipedia.org/wiki/Aircraft_design_process
4	https://www.youtube.com/watch?v=WDkP8oEjzzg

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE23	Composite Product Processing Methods	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To impart knowledge on the material selection for fabricating composite products
2	To impart an idea about the product development and manufacturing of composites.
3	To acquire adequate knowledge about the manufacturing of thermoset composites
4	To acquire adequate knowledge about the manufacturing of thermoplastic composites
5	To gain knowledge on joining, machining and cutting of composites

UNIT – I	MATERIAL SELECTION	9

Reinforcements - Glass Fiber Manufacturing - Carbon Fiber Manufacturing - Aramid Fiber Manufacturing - Matrix Materials - Thermoset Resins - Thermoplastic Resins - Fabrics – Prepregs - Preforms - Molding Compound - Honeycomb and Other Core Materials - The Need for Material Selection - Reasons for Material Selection - Material Property Information - Steps in the Material Selection Process - Material Selection Methods.

UNIT – II	PRODUCT DEVELOPMENT AND DESIGN FOR MANUFACTURING	9

Product Development Process - Reasons for Product Development - Importance of Product Development - Concurrent Engineering - Product Life Cycle - Phases of Product Development - Design Review - Failure Modes and Effects Analysis (FMEA) - Design Problems - DFM – DFM Implementation Guidelines - Design Evaluation Method - Design for Assembly (DFA).

UNIT – III	MANUFACTURING PROCESSES FOR THERMOSET COMPOSITES	9

Prepreg Lay-Up Process - Wet Lay-Up Process - Spray-Up Process - Filament Winding Process - Pultrusion Process - Resin Transfer Molding Process - Structural Reaction Injection Molding (SRIM) Process - Compression Molding Process - Roll Wrapping Process - Injection Molding of Thermoset Composites.

UNIT – IV	MANUFACTURING PROCESSES FOR THERMOPLASTIC COMPOSITES	9

Thermoplastic Tape Winding - Thermoplastic Pultrusion Process - Compression Molding of GMT - Hot Press Technique - Autoclave Processing - Diaphragm Forming Process - Injection Molding.

UNIT – V	JOINING, MACHINING AND CUTTING OF COMPOSITES	9

Adhesive Bonding - Failure Modes in Adhesive Bonding - Basic Science of Adhesive Bonding - Types of Adhesives - Advantages of Adhesive Bonding over Mechanical Joints – Disadvantages of Adhesive Bonding - Adhesive Selection Guidelines - Surface Preparation Guidelines – Design Guidelines for Adhesive Bonding- Theoretical Stress Analysis for Bonded Joints – Mechanical Joints - Preparation for the Bolted Joint-Purposes of Machining - Challenges during Machining of Composites - Failure Mode during Machining of Composites - Cutting Tools - Types of Machining Operations - Cutting Operation - Drilling Operation.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To select the suitable material for making composite products.	Evaluating
CO2	To gain knowledge on product development and manufacturing of composites.	Evaluating
CO3	To select the most appropriate manufacturing process for fabricating thermoset composite components.	Applying
CO4	To select the most appropriate manufacturing process for fabricating thermoplastic composite components	Analyzing
CO5	To gain knowledge about the joining, machining and cutting of composites	Analyzing

REFERENCE BOOKS:

1	Allen Baker, "Composite Materials for Aircraft Structures", AIAA Series, 2nd Edition, 2004.
2	Autar K Kaw, "Mechanics of Composite Materials", CRC Press, 2nd edition, 2005
3	Lubing, "Handbook on Advanced Plastics and Fibre Glass", Von Nostran Reinhold Co., New York, 1989.
4	Sanjay K. Mazumdar, "Composites Manufacturing: Materials, Product, and Process Engineering", CRC Press, Washington, D.C, 2002.

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1	https://en.wikipedia.org/wiki/Composite_material
2	https://onlinecourses.nptel.ac.in/noc19_me67/preview
3	https://onlinecourses.nptel.ac.in/noc20_me29/preview
4	https://www.composite.triovision.in/?gclid=EAIaIQobChMIodm4q4HahAMVQxd7Bx1BJAWNEAAYASAAEgJZvvD_BwE

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

ARso

PPAR3PE24	Helicopter Aerodynamics	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	This course will make students to provide with introductory concepts of types of rotorcraft
2	This course imparts knowledge on the fundamental aspects of helicopter aerodynamics and performance of helicopters
3	This course will provide basic knowledge on the performance of helicopters
4	This course presents stability and control aspects of helicopters
5	This course will explore the basic aerodynamic design aspects of helicopters

UNIT – I **INTRODUCTION** **9**

Types of rotorcraft – autogyro, gyrodyne, helicopter, Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti-torque pedals

UNIT – II **HELICOPTER AERODYNAMICS** **9**

Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, vortex theory, rotor in hover, rotor model with cylindrical wake and constant circulation along blade, free wake model, Constant chord and ideal twist rotors, Lateral flapping, Coriolis forces, reaction torque, compressibility effects, Ground effect.

UNIT – III **PERFORMANCE** **9**

Hover and vertical flight, forward level flight, Climb in forward flight, optimum speeds, Maximum level speed, rotor limits envelope – performance curves with effects of altitude.

UNIT – IV **STABILITY AND CONTROL** **9**

Helicopter Trim, Static stability – Incidence disturbance, forward speed disturbance, angular velocity disturbance, yawing disturbance, Dynamic Stability.

UNIT – V **AERODYNAMIC DESIGN** **9**

Blade section design, Blade tip shapes, Drag estimation – Rear fuselage upsweep, vibration problem of Helicopter blades.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Describe and compare possible helicopter structures and configurations	Evaluating
CO2	Identify features of aerodynamic components of rotary wing aircraft and its performance	Evaluating
CO3	Describe the aerodynamic characteristics that affect rotary wing flight	Applying

CO4	Idea about the factors that influence helicopter stability	Analyzing
CO5	Gain knowledge of helicopter controls and vibration analysis of helicopter blades	Analyzing

REFERENCE BOOKS:

1	Gessow.A and Meyers,GC,"Aerodynamics of the Helicopter", Macmillan and Co., New York,1982.
2	John Fay, "The Helicopter", Himalayan Books, New Delhi, 1995
3	Lalit Gupta, "Helicopter Engineering", Himalayan Books, New Delhi, 1996
4	Lecture Notes on Helicopter Technology, Department of Aerospace Engineering, IIT – Kanpur and Rotary Wing aircraft R&D center, HAL, Bangalore, 1998
5	Seddon,J,"Basic Helicopter Aerodynamics", AIAA Education series, Blackwell scientific publications, U.K, 1990

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://nptel.ac.in/courses/101104017
2	https://www.youtube.com/watch?v=3gQ9AfgkaGM&list=PL2tY7KqPLKuRoxnHXr827FUD3yFSF_o-2
3	https://www.youtube.com/watch?v=iG0WC2ewM4I
4	https://en.wikipedia.org/wiki/Helicopter

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE25	High Speed Jet Flows	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get insight into the basic aspects of jets and types of jets
2	To learn the basic properties of jets and its characteristics
3	To get knowledge on various active and passive jet control methods
4	To gain knowledge into the basic aspects of jet acoustics
5	To acquire in-depth knowledge on how and what type of control methods can be implemented practically

UNIT – I	INTRODUCTION	9

Properties of Turbulent Jets-Fundamental Concepts, Submerged Jets- Velocity Profiles in a Submerged Jet- Spread of a turbulent submerged jet- Lines of Constant Velocity in a Submerged Jet. Velocity Variation along the Axis of a Submerged jet, Velocity, Temperature, and Concentration Profiles in a Turbulent Jet Spreading into an External Stream of Fluid- Spread of a Turbulent Jet into a Co-flowing or Counter-flowing External Stream- Turbulence Characteristics in a Free Jet.

UNIT – II	JETS	9

Types of Jets-Plane free-jets. Round jets. Plane jets in a co-flowing stream. Round jet in Co flowing stream- Swirling jets- Radial jets- Wall jets- Jet Characteristics & Entrainment, Mathematical treatment of jet profiles- Semi-empirical Theories. Mixing Layers- Computational and Experimental Techniques for Studying the Jets.

UNIT – III	ACTIVE JETCONTROL METHODS	9

Active control methods- Actuators-Fluidic, Thermal, Acoustic, Piezoelectric, Electromagnetic, MEMS,Synthetic Jets, Controls and Sensors, Applications.

UNIT – IV	PASSIVE JET CONTROL METHODS	9

Passive control techniques- Tabs, Grooves, Chevrons, non-circular nozzles, Notches & wires, vortex generators. Optical Flow Visualization, Applications.

UNIT – V	JET ACOUSTICS	9

Introduction to Jet Acoustics – Types of jet noise – Source of generation- Travelling wave solution, standing wave solution – multi-dimensional acoustics-Theoretical Concepts of Jet Noise Generation and Suppression–Jet Noise suppression techniques – applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To acquire knowledge on the unique features of jet flows	Evaluating
CO2	To analyse the characteristics of jets	Evaluating
CO3	To have through knowledge on active and passive control methods of jets	Applying

CO4	To acquire knowledge on jet acoustics and methods for suppression of jet noise	Analyzing
CO5	To demonstrate various experimental techniques to determine jet characteristics	Analyzing

REFERENCE BOOKS:

1	Ethirajan Rathakrishnan, "Applied Gas Dynamics", John Wiley, New York, 2010
2	Liepmann and Roshko, "Elements of Gas Dynamics", Dover Publishers, 2017.
3	Rathakrishnan E., "Gas Dynamics", Prentice Hall of India, New Delhi, 5th edition, 2014
4	Shapiro, AH, "Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I & II", Ronald Press, New York, 1953.

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1	https://archive.nptel.ac.in/courses/101/105/101105024/
2	https://onlinecourses.nptel.ac.in/noc24_me36/preview
3	https://archive.nptel.ac.in/courses/101/105/101105088/
4	https://www.youtube.com/watch?v=2rwXMwas5cU

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE26	Smart Materials and Structural Health Monitoring	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To get basic idea on the fundamentals of structural health monitoring
2	To impart knowledge in the areas of vibration based techniques in structural health monitoring, fibre optics and piezo electric sensors
3	To gain knowledge on the fundamentals of fabrication, modelling, analysis, and design of smart materials and structures
4	To get exposed to the state of the art of smart materials and systems
5	To impart knowledge on spanning piezoelectrics, shape memory alloys, electro active polymers, mechanochromic materials and fibre optics

UNIT – I	STRUCTURAL HEALTH MONITORING	9

An Overview of Structural Health Monitoring, Structural Health Monitoring and Smart Materials, Structural Health Monitoring versus Non Destructive Evaluation A broad Overview of Smart Materials Overview of Application Potential of SHM Notable Applications of SHM – Aerospace Engineering. Structural health monitoring of composites – Repair investigation using SHM.

UNIT – II	OVERVIEW OF SMART MATERIALS	9

Introduction to Smart Materials, Principles of Piezoelectricity, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids.

UNIT – III	SMART COMPOSITES	9

Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams , Vibration Control using SHM –introduction to FE formulation Constitutive Relationship - Element Stiffness Matrix for High Precision Finite Element -Element Mass Matrix for High Precision Finite Element - Developing Actuator and Sensor Influence Matrix .Delamination Sensing using Piezo Sensory Layer.

UNIT – IV	INTELLIGENT SYSTEMS AND NEURAL NETWORKS	9

Operational evaluation -.Data acquisition- Feature extraction-Statistical model development for feature discrimination -Data Cleansing – Normalization-Data Fusion – Compression – Statistical model building - Supervised pattern recognition - Unsupervised pattern recognition – Signal processing – Fuzzy C means- K means – Kohenon's Self organization mapping-Fundamentals of Wavelet analysis –Life Prediction.

UNIT – V	ADVANCES IN SMART STRUCTURES & MATERIALS	9

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design of Chemical and Bio-Chemical sensing in structural Assessment – Absorptive chemical sensors – Spectroscopes – Fibre Optic Chemical Sensing Systems and Distributed measurement.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	To familiarize with the fundamentals of history of SHM.	Evaluating
CO2	To provide a systematic approach to SHM process	Evaluating
CO3	To have knowledge of the various smart materials used for aerospace applications	Applying
CO4	To familiarize with the non-destructive test techniques relevant to SHM	Analyzing
CO5	To provide hands-on experience with experimental modal analysis	Analyzing

REFERENCE BOOKS:

1	Brian Culshaw, "Smart Structures,and Materials", Artech House, 2000
2	Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, "Structural Health Monitoring", Wiley - ISTE, 2006.
3	Douglas E Adams, "Health Monitoring of Structural Materials and Components-Methods with Applications", John Wiley and Sons, 2007
4	Laurene Fausett, "Fundamentals Of Neural Networks", Pearson publishers, 1994
5	Victor Giurglutiu, "Structural Health Monitoring with Wafer Active Sensors", Academic Press Inc, 2007.

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/112/104/112104160/
2	https://onlinecourses.nptel.ac.in/noc23_ae19/preview
3	https://en.wikipedia.org/wiki/Structural_health_monitoring
4	https://www.aendt.com/plus/listb.html?gad_source=2&gclid=EAIaIQobChMItqzC34PahAMVaYJLBR2zOA1sEAAYASAAEgLLpfD_BwE

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE27	Artificial Intelligence and Machine Learning	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To gain knowledge on artificial intelligence
2	To understand the concepts of Machine Learning
3	To appreciate supervised learning and their applications
4	To appreciate the concepts and algorithms of unsupervised learning
5	To understand the theoretical and practical aspects of Probabilistic Graphical Models

UNIT – I **ARTIFICIAL INTELLIGENCE** **9**

Artificial intelligence – Basics – Goals of artificial intelligence– AI techniques–problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots.

UNIT – II **INTRODUCTION TO MACHINE LEARNING** **9**

Machine Learning–Types of Machine Learning –Machine Learning process- preliminaries, testing - Machine Learning algorithms, turning data into Probabilities, and Statistics for Machine Learning - Probability theory – Probability Distributions – Decision Theory.

UNIT – III **SUPERVISED LEARNING** **9**

Linear Models for Regression – Linear Models for Classification- Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Models – Decision Tree Learning – Bayesian Learning, Naïve Bayes – Ensemble Methods, Bagging, Boosting, Neural Networks, Multi-layer Perceptron, Feed- forward Network, Error Back propagation - Support Vector Machines.

UNIT – IV **UNSUPERVISED LEARNING** **9**

Clustering- K-means – EM Algorithm- Mixtures of Gaussians –Dimensionality Reduction, Linear Discriminant Analysis, Factor Analysis, Principal Components Analysis, Independent Components Analysis.

UNIT – V **PROBABILISTIC GRAPHICAL MODELS** **9**

Graphical Models – Undirected Graphical Models – Markov Random Fields – Directed Graphical Models –Bayesian Networks – Conditional Independence properties – Markov Random Fields- Hidden Markov Models – Conditional Random Fields (CRFs).

TOTAL: 45 PERIODS

COURSE OUTCOMES		**Blooms Level**
CO1	Optimize the robots using Artificial Intelligence	Evaluating
CO2	Design a learning model appropriate to the application	Evaluating
CO3	Implement Probabilistic Discriminative and Generative algorithms for an application of your choice and analyze the results	Applying
CO4	Use a tool to implement typical Clustering algorithms for different types of applications	Analyzing
CO5	Identify applications suitable for different types of Machine Learning with suitable justification	Analyzing

REFERENCE BOOKS:	
1	Christopher Bishop,"Pattern Recognition and Machine Learning" Springer, 2007
2	Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Chapman and Hall,CRC Press, Second Edition,2014
3	Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.
4	Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Third Edition, 2014
5	Tom Mitchell, "Machine Learning", McGraw-Hill,1997

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:	
1	https://onlinecourses.nptel.ac.in/noc22_cs56/preview
2	https://en.wikipedia.org/wiki/Artificial_intelligence
3	https://www.youtube.com/watch?v=mJeNghZXtMo
4	https://nptel.ac.in/courses/106106202

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPAR3PE28	Aircraft Guidance and Control	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1	To learn about the aircraft equations of motion and method of linearization.
2	To impart knowledge on the operating principle of guidance law.
3	To gain knowledge on various augmentation systems
4	To get familiarize with the concepts of longitudinal stability and to design the longitudinal autopilot.
5	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, AutomaticlateralBeamGuidance.IntroductiontoFly-by-wireflightcontrol 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 schemes.

TOTAL: 45 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Explain the equations governing the aircraft dynamics and the process of linearizing them.	Evaluating
CO2	Define the various guidance schemes & requirements for aircrafts and missiles	Evaluating
CO3	Explain the principle of stability and control augmentation systems	Applying
CO4	Explain the oscillatory modes and methods of suppressing them	Analyzing
CO5	Design the controller for lateral, longitudinal and directional control of aircrafts.	Analyzing

REFERENCE BOOKS:

1	Thomas R Yechout, Steven L Morris, David E Bossert, Wayne F Hallgren, James K Hall, "Introduction to Aircraft Flight Mechanics", AIAA Education series, 2014
2	Pierre T. Kabamba, Anouck R. Girard, "Fundamentals of Aerospace Navigation and Guidance", Cambridge university press, 2014.
3	CollinsonRPG,"IntroductiontoAvionics",ChapmanandHall,India,1996
4	BlakeLock,JH, "AutomaticcontrolofAircraftandmissiles",JohnWileySons,NewYork, 1990
5	Stevens BL and Lewis FL, "Aircraft control &simulation",JohnWileySons, NewYork,1992

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1	https://archive.nptel.ac.in/courses/101/108/101108056/
2	https://archive.nptel.ac.in/courses/101/104/101104062/
3	http://www.digimat.in/nptel/courses/video/101108057/L16.html
4	https://archive.nptel.ac.in/courses/101/108/101108054/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	-	1	-
CO2	3	2	1	-	1	-
CO3	3	2	1	-	1	-
CO4	3	2	1	-	1	-
CO5	3	2	1	-	1	-

PPCC1AC01	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES:

1	Teach how to improve writing skills and level of readability
2	Tell about what to write in each section
3	Summarize the skills needed when writing a Title
4	Infer the skills needed when writing the Conclusion
5	Ensure the quality of paper at very first-time submission

UNIT – I	INTRODUCTION TO RESEARCH PAPER WRITING	6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT – II	PRESENTATION SKILLS	6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing andPlagiarism, Sections of a Paper, Abstracts, Introduction

UNIT – III	TITLE WRITING SKILLS	6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills areneeded when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT – IV	RESULT WRITING SKILLS	6

Skills are needed when writing the Methods, skills needed when writing the Results; skills are neededwhen writing the Discussion- Skills are needed when writing the conclusions.

UNIT – V	VERIFICATION SKILLS	6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- timesubmission.

TOTAL: 30 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Understand that how to improve your writing skills and level of readability	Analyzing
CO2	Learn about what to write in each section	Analyzing
CO3	Understand the skills needed when writing a Title	Remembering
CO4	Understand the skills needed when writing the Conclusion	Analyzing
CO5	Ensure the good quality of paper at very first-time submission	Remembering

REFERENCE BOOKS:

1	Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2	Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3	Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006

AR91

4	Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998

WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:

1	https://archive.nptel.ac.in/courses/110/105/110105091/
2	https://onlinecourses.nptel.ac.in/noc20_hs06/preview
3	https://onlinecourses.nptel.ac.in/noc22_hs05/preview
4	https://www.youtube.com/watch?v=Xp2PVO3do34

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	2	2	1	2	2	1
CO3	3	2	1	3	3	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1

AR92

PPCC1AC02	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES:

1	Summarize basics of disaster
2	Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
3	Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
4	Describe an understanding of standard so humanitarian response and practical relevance in specific types of disasters and conflict situations.
5	Develop the strengths and weaknesses of disaster management approaches

UNIT – I	INTRODUCTION	6

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude

UNIT – II	REPERCUSSIONS OF DISASTERS AND HAZARDS	6

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT – III	DISASTER PRONE AREAS IN INDIA	6

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post- Disaster Diseases and Epidemics

UNIT – IV	DISASTER PREPAREDNESS AND MANAGEMENT	6

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT – V	RISK ASSESSMENT	6

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL: 30 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Ability to summarize basics of disaster	Remembering
CO2	Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.	Analyzing
CO3	Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.	Remembering
CO4	Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.	Remembering
CO5	Ability to develop the strengths and weaknesses of disaster management approaches.	Remembering

REFERENCE BOOKS:

1	GoelS.L.,Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt.Ltd.,New Delhi,2009.
2	NishithaRai,SinghAK,"DisasterManagementinIndia:Perspectives,issuesandstrategies "'NewRoyalbookCompany,2007.
3	Sahni,PardeepEt.Al.,"DisasterMitigationExperiencesAndReflections",PrenticeHallOfIndia,New Delhi,2001

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1	https://nptel.ac.in/courses/105104183
2	https://onlinecourses.swayam2.ac.in/cec19_hs20/preview
3	https://www.youtube.com/watch?v=TB97oX7ANGo

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	2	2	1	2	2	1
CO3	3	2	1	3	3	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1

AR94

PPCC2AC01	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES:

1	Understand the premises in forming the twin theme so liberty and freedom from a civil rights perspective.
2	To address the growth of Indian opinion regarding modern Indian intellectuals'constitutional
3	Role and entitlement to civil and economic rights as well as the emergence nationhood in the early year s of Indian nationalism.
4	To address the role of socialism in India after the commencement of the BolshevikRevolutionin1917and its impact on the initial drafting of the Indian Constitution.
5	Understandthepremisesinformingthetwinthemesoflibertyandfreedomfromacivilrightperspective.

UNIT – I	HISTORY OF MAKING OF THE INDIAN CONSTITUTION	5

History, Drafting Committee, (Composition & Working)

UNIT – II	PHILOSOPHY OF THE INDIAN CONSTITUTION	5

Preamble, Salient Features

UNIT – III	CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES	5

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom ofReligion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of StatePolicy, Fundamental Duties.

UNIT – IV	ORGANS OF GOVERNANCE	5

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications,Powers and Functions.

UNIT – V	LOCAL ADMINISTRATION	5

District's Administration head: Role and Importance, □Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT – VI	ELECTION COMMISSION	5

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners -Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

COURSE OUTCOMES		Blooms Level
CO1	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.	Remembering
CO2	Discuss the intellectual origins of the framework of argument that in formed the conceptualization of social reforms leading to revolution in India.	Remembering
CO3	Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.	Remembering
CO4	Discuss the passage of the Hindu Code Bill of1956.	Remembering

REFERENCE BOOKS:	
1	TheConstitution of India,1950(BareAct),Government Publication.
2	Dr.S.N.Busi,Dr.B.R.Ambedkar framing of IndianConstitution,1st Edition,2015.
3	M.P.Jain,Indian Constitution Law,7th Edn.,LexisNexis,2014.
4	D.D.Basu,Introduction to the Constitution of India,LexisNexis, 2015.
WEBSITE REFERENCE / NPTEL/ SWAYAM/ MOOC REFERENCE:	
1	https://archive.nptel.ac.in/courses/129/106/129106003/
2	https://onlinecourses.nptel.ac.in/noc20_lw03/preview
3	https://archive.nptel.ac.in/courses/129/106/129106002/

CO-PO MAPPING

COs	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	1	1	1
CO2	2	2	1	2	2	1
CO3	3	2	1	3	3	1
CO4	2	2	1	2	2	1
CO5	2	2	1	2	2	1

PPCC2AC02	நற்றமிழ் இலக்கியம்	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES:

UNIT – I	சங்க இலக்கியம்	6

1. தமிழின் Fவக்க நூல் ததொல்கொப்பியம் –எழுத்F, தB◻ொல், தபொருள்
2. அகத ொனூறு)82) - இயற்கக இன்னிகB அரங்கம்
3. குறிஞ்சிப் பொட்டின் மலரக் ொட்சி
4. புற ொனூறு) 95,195) - பபொகர ிறுத்திய ஒளகவயொர்

UNIT – II	அறநநறித்தமிழ்	6

1. அறத றி வகுத்த திருவள்ளுவர்
   - அறம் வலியுறுத்தல், அன் புகடகம, ஒப்புரவறிதல் அறிதல், ஈகக, புகழ்
2. பிற அறநூல்கள் -இலக்கிய மரு ்F

ஏலொதி, சிறுபஞ்Bமூலம், திரிகடுகம், ஆ◻ொரக்பகொகவ (தூய் கமகய வலியுறுத்Fம் நூல்)

UNIT – III	இரட்டடக் காப்பியங்கள்	6

1. கண் ணகியின் புரட்சி - சிலப்பதிகொர வழக்குகர கொகத

BமூகபBகவ இலக்கியம் மணிபமகல - சிகறக்பகொட்டம் அறக்பகொட்டமொகிய கொகத

UNIT – IV	அருள் நநறித் தமிழ்	6

1. சிறுபொணொற்றுப்பகட - பொரி முல் கலக்குத் பதர் குடுத்தF, பபகன் மயிலுக்கு பபொரக் வ தகொடுத்தF, அதியமொன் அவ் கவக்கு த ல் லிக்கனி தகொடுத்தF, அரBர் பண் புகள்
2. ற்றிகண - அன் கனக்குரிய புன் கன சிறப்பு
3. திரும ்திரம் (617, 618) -- இயமம் ியமம் விதிகள்
4. தர்ம◻ொகலகய ிறுவிய வள்ளலொர்
5. புற ொனூறு - சிறுவபன வள்ளலொனொன்
6. அக ொனூறு (4) – வண் டு

   ற்றிகண (11) – ண்டு

   கலித்ததொக (11) -யொகன , புறொ ஐ

   ்திகண 50 (27) - மொன்

ஆகியகவ பற்றிய தBய்திகள்

UNIT – V	நவீன தமிழ் இலக்கியம்	6

1. உகர கடத்தமிழ்
   - தமிழின் முதல் புதினம்
   - தமிழின் முதல் சிறுகதை

- கட்டுகர இலக்கியம்
- பயண இலக்கியம்
- ொடகம்

2. ொட்டு விடுதகல பபொரொட்டமும் தமிழ் இலக்கியமும்
3. Bமுதொய விடுதகலயும் தமிழ் இலக்கியமும்
4. தபண் விடுதகலயும் விளிம் பு ிகலயனரின் பமம்பொட்டில் தமிழ் இலக்கியமும்
5. அறிவியல் தமிழ்
6. இகணயத்தில் தமிழ்

சுற்றுசூழல் பமம்பொட்டில் தமிழ் இலக்கியமும்

TOTAL: 30 PERIODS

தமிழ் இலக்கிய நெளியீடுகள் / புத்தகங் கள்

1	தமிழ் இகணய கல்விக்கழகம் (Tamil Virtual University) - www.tamilvu.org
2	தமிழ் விக்கிப்பீடியொ - (Tamil Wikipedia) - https://ta.wikipedia.org
3	தர்மபுர ஆதீன தவளியீடு
4	வொழ்வியல் களஞ்சியம் - தமிழ்ப் பல்ககலக்கழகம், தஞ□ொலூர்
5	தமிழ்ககலக் களஞ்சியம் –தமிழ் வளர□் ்சித்Fகற (thamilvalarchithurai.com)
6	அறிவியல் களஞ்சியம் - தமிழ்ப் பல்ககலக்கழகம், தஞ□ொலூர்

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