B.M.S.COLLEGE OF ENGINEERING, BENGALURU

Autonomous College under VTU

DEPARTMENT OF AEROSPACE ENGINEERING

Syllabus for UG Programme - III to VIII Semesters

Department Vision

To become a center of excellence for imparting quality education, conducting fundamental research and innovation in the field of aerospace engineering.

Department Mission

- To empower the students with the fundamentals for a successful aerospace engineering career.
- To continue their education through deep learning and practical exposure.
- Provide state-of-the art laboratories, infrastructure facilities and skilled man power for research and consultancy.
- To collaborate with industries, research organizations and institutes for developing sustainable and inclusive technologies, interdisciplinary research, and internship activities.
- To develop young entrepreneurs with engineering ethics and social responsibility.

Semester Wise Credit Distribution

I	II	III	IV	V	VI	VII	VIII	Total
20	20	25	25	25	25	19	16	175

III Semester

Course Code	Course Title	Teaching Department	Credits			Total Credits	Contact Hours	Marks	
			L	T	P			CIE	SEE
19MA3BS EM3	Engineering Mathematics - 3	MA	3	1	0	4	5	50	50
19AE3DC IAE	Introduction to Aerospace Engineering	AE	4	0	0	4	4	50	50
19AE3DC ATD	Aero -Thermodynamics	AE	3	0	0	3	3	50	50
19AE3DC AFM	Aero - Fluid Mechanics	AE	3	0	1	4	5	50	50
19AE3DC MAE	Materials for Aerospace Engineering	AE	3	0	0	3	3	50	50
19AE3DC MTA	Manufacturing Technology for Aerospace Engineering	AE	3	0	1	4	5	50	50
19AE3DC CTA	Computer Aided Tools for Aerospace Engineering	AE	1	0	1	2	3	50	50
19HS3IC EVS	Environmental Studies	HS	1	0	0	1	1	50	50
	Total Credits		21	1	3	25	29	Total	

IV Semester

Course Code	Course Title	Teaching Department	Credits			Total Credits	Contact Hours	Marks	
			L	T	P			CIE	SEE
19MA4BS EM4	Engineering Mathematics- 4	MA	3	1	0	4	5	50	50
19AE4DC AAI	Aircraft Systems, Avionics and Instrumentation	AE	4	0	0	4	4	50	50
19AE4DC AHT	Aero-Heat and Mass Transfer	AE	3	0	0	3	3	50	50
19AE4DC BAD	Basic Aerodynamics	AE	3	0	1	4	5	50	50
19AE4DC ASM	Aero - Solid Mechanics	AE	3	0	1	4	5	50	50
19AE4DC ADD	Aerospace Drawing and Drafting	AE	2	1	1	4	6	50	50
19IC4HS CPH	Constitution of India, Professional Ethics and Human Rights	HS	1	0	0	1	2	50	50
20HS4MCKAN	Kannada Language	HS	1	0	0	1	1	50	50
19AE4NC PDC	Personality Development and Communication Skills	Non-Credit Mandatory Course							
	Total Credits		20	2	3	25	31	Total	

V Semester

Course Code	Course Title	Teaching Department	Credits			Total Credits	Contact Hours	Marks	
			L	T	P			CIE	SEE
20AE5DC MAM	Machines and Mechanisms	AE	3	1	0	4	4	50	50
20AE5DC BPR	Basic Propulsion	AE	3	0	1	4	3	50	50
20AE5DC AAD	Advanced Aerodynamics	AE	3	0	1	4	5	50	50
20AE5DC ICT	Introduction to Control Theory	AE	3	0	0	3	5	50	50
20AE5DCBFM	Basic Flight Mechanics	AE	3	0	1	4	5	50	50
20AE5DE ***	Professional Elective - 1	AE	3	0	0	3	3	50	50
20AE6DCMP1	Mini-Project Work -1 (multi-discipline)	AE	0	0	1	1	2	50	50
20HS5ICEPP	Entrepreneurship	HS	2	0	0	2	2	50	50
20AE5NCYSM	Yoga & Stress Management	Non-credit Mandatory Course							
	Total Credits		20	1	4	25	29	Total	

VI Semester

Course Code	Course Title	Teaching Department	Credits			Total Credits	Contact Hours	Marks	
			L	T	P			CIE	SEE
20AE6DC AST	Aerospace Structures	AE	3	0	1	4	5	50	50
20AE6DC COM	Combustion	AE	3	0	1	4	5	50	50
20AE6DC EDO	Engineering Design and Optimization	AE	3	0	0	3	3	50	50
20AE6DC DSM	Flight Dynamics and Space Mechanics	AE	3	0	1	4	5	50	50
20AE6DC VTA	Vibration Theory and Aero-elasticity	AE	3	0	0	3	3	50	50
20AE5DC ***	Professional Elective – 2	AE	3	0	0	3	3	50	50
20***** ***	Open Elective - 1	-	3	0	0	3	3	50	50
20AE6DC MP2	Mini Project - 2	AE	0	0	1	1	2	50	50
	Total Credits		21	0	4	25	29	Total	

VII Semester

Course Code	Course Title	Teaching Department	Credits			Total Credits	Contact Hours	Marks	
			L	T	P			CIE	SEE
21AE8DC MRO	Maintenance, Repair and Overhaul	BS	2	0	0	2	2	50	50
21AE7DC AVD	Aerospace Vehicle Design and Analysis	AE	2	1	1	4	6	50	50
21AE7DC AVS	Avionic Systems	AE	3	1	0	4	5	50	50
21AE7DE ***	Professional Elective – 3	AE	3	0	0	3	3	50	50
21***** ***	Open Elective - 2	-	3	0	0	3	3	50	50
21IC7HS PMF	Project Management and Finance	-	1	0	0	1	2	50	50
21HS7DC PW1	Major Project Work Phase - 1	AE	0	0	3	3	2	50	50
	Total Credits		14	2	4	20	27	Total	

VIII Semester

Course Code	Course Title	Teaching Department	Credits			Total Credits	Contact Hours	Marks	
			L	T	P			CIE	SEE
21IC7HS HFG	Human Factors and Ergonomics	HS	2	0	0	2	2	50	50
21***** ***	Open Elective – 3	-	3	0	0	3	3	50	50
21AE8DC PW2	Major Project Work Phase- 2	AE	0	0	10	10	2	50	50
21AE8DC SEM	Technical Seminar	AE	0	0	1	1	0	50	50
	Total Credits		5	0	11	16	7	Total	

Department Electives

PE - 1	PE - 2	PE - 3
Advanced Thermodynamics	Turbulence in Fluid Flow	Rotor Dynamics
Helicopter Dynamics	Hypersonic Aerothermodynamics	Computational Fluid Dynamics
-	Finite Element Method	-

Aerospace Open Electives

OE - 1	OE - 2	OE - 3
Fatigue and Fracture Mechanics		
-		

Syllabus for III Semester

COURSE		CREDITS			MARKS	
NAME	ENGINEERING MATHEMATICS - 3	L	T	P	CIE	SEE
CODE	19MA3BS EM3	3	1	0	50	50

Course objectives:
1. To make the students conversant with concepts of Linear Algebraic systems, Fourier series, Fourier Transforms and develop computational skills using efficient numerical methods for problems arising in science and engineering.

Course pre- requisite: Basic concepts of Trigonometry, methods of differentiation, methods of integration, solution of ordinary differential equations.

Unit-1 **9 hours**

Matrices: Introduction: Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of a system of linear equations and solution. Solution of a system of non-homogenous equations: Gauss elimination method, Gauss-Seidel method, LU decomposition method, eigenvalues and eigenvectors of matrices, reduction of a matrix to diagonal form.

Unit-2 **9 hours**

Fourier series: Introduction: Dirichlet's conditions, Fourier series of periodic functions of period 2l, Fourier series of functions having points of discontinuity. Applications: Fourier series of typical waveforms like saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform, exponential Fourier series, practical harmonic analysis.

Unit-3 **9 hours**

Fourier transforms: Infinite Fourier transform: Fourier Sine and Cosine transforms, properties, Inverse transforms. Convolution theorem, Parseval's identities.

Unit-4 **9 hours**

Numerical methods: Solution of algebraic and transcendental equations: Newton-Raphson method.Finite Differences and interpolation: Forward differences, backward differences. Newton- Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's interpolation formula, Lagrange's inverse interpolation. Numerical integration: Simpson's $1/3^{rd}$ rule, Simpson's $3/8^{th}$ rule, Weddle's rule. Numerical solution of ordinary differential equations: modified Euler's method, Runge-Kutta method of fourth order.

Unit-5 **9 hours**

Calculus of variations: Variation of a functional, Euler's equation, variational problems. Applications: Hanging cable problem, Brachistochrone problem.

Z -transforms: Definition, Properties, Transforms of standard functions, Inverse transforms. Solution of difference equations using Z- transforms.

Course outcomes:
After studying this course, students will be able to:
1. Apply Numerical techniques to solve problems arising in engineering.

2. Demonstrate an understanding of Fourier Series, Fourier Transforms and Z- Transforms.
3. Apply the concepts of calculus to functionals.

Textbook:

1. Grewal B. S., Higher Engineering Mathematics, 43rd ed., Khanna Publishers, 2014.
2. Dennis G. Zill and Cullen, Jones, Advanced Engineering Mathematics, 4th ed., Bartlett India Pvt. Ltd, 2011.

References:

1. Ramana B. V., Higher Engineering Mathematics, Tata McGraw Hill, 2007.
2. Kreyszig E., Advanced Engineering Mathematics, 10th ed. Vol.1 and Vol.2, Wiley-India,2014.

Web References:

1.https://nptel.ac.in/courses/111103021/22 (Fourier series and Transforms, Heat and Wave Equations)
2.https://nptel.ac.in/courses/122104018/2 (Numerical Methods)
3.https://nptel.ac.in/courses/111104025/ (Calculus of variation)

COURSE		CREDITS			MARKS	
NAME	INTRODUCTION TO AEROSPACE ENGINEERING	L	T	P	CIE	SEE
CODE	19AE3DC IAE	4	0	0	50	50

Course objectives:
1. To introduce an overview of aerospace engineering.
2. To provide an exposure to the disciplines and sub groups in aerospace engineering.
3. To explore the future challenges and prospectus in aerospace.

Course pre- requisite: Engineering Mathematics - Calculus, Engineering Mechanics - Statics, Engineering Mechanics – Dynamics.

Unit-1 **9 hours**

Introduction: History of aviation and space flight; Classification of aircraft and space vehicles; Functions of major components of airplane and space vehicles; Subdivision of aerospace engineering; International standard atmosphere; Elements of aerodynamics and flight mechanics, propulsion, control, structures, systems, aerospace materials and aircraft instruments.

Unit-2 **9 hours**

Basic aerodynamics, flight and space mechanics: Importance of aerodynamics; Airfoils and streamlines; Forces acting on an airplane - lift and drag, types of drag; Factors affecting lift and drag; Types of flow and their governing equations; Speed and power. Straight and level flight; Conditions for minimum drag and minimum power; Gliding, cruise and climbing flight; Range and endurance; Takeoff and landing; V-n diagram. Basic orbital mechanics, Types of orbits, Kepler's Laws of planetary motion.

Stability and control: Concepts of static and dynamic stability and control - yaw and sideslip; Dihedral effect; Rudder requirements – directional and spiral divergence; Dutch roll; Autorotation and spin; Basics of space vehicle control systems.

Unit-3 **9 hours**

Propulsion: Aircraft propulsion; Rocket propulsion; Power plant classification, principles of operation and areas of their application.

Aircraft structures and materials: Introduction; General types of construction; Typical wing and fuselage structure; Metallic and non-metallic materials for aircraft application; Use of aluminum alloy, titanium, stainless steel and composite materials.

Unit-4 **9 hours**

Aircraft instruments: Instrument displays; Introduction to navigation instruments; Basic air data systems and probes- Mach meter, air speed indicator, vertical speed indicator, Altimeter, gyro based instruments.

Aircraft systems: Mechanical systems and their components; Hydraulic and pneumatic systems; Oxygen system; Environmental control system; Fuel system; Oxygen system; Electrical systems, Flight deck and cockpit systems; Navigation system, communication system; Power generation systems; Fire protection, Ice and rain protection system.

Unit-5 **9 hours**

Challenges in aerospace engineering: Modern developments in aviation; Future challenges –safety, light, high speed, fuel efficient vehicles and autonomous operations; Aerodynamic, structural and crashworthiness, manufacturing and environmental considerations for commercial and military airplanes; Increased space vehicle telemetric and addressing its security concerns; Global perspectives of aerospace industry - vision and mission; Indian aerospace activities - leading private and public sector organizations and their roles.

Course outcomes:
After studying this course, students will be able to:
1. Understand and the general concepts and problems of aerospace engineering.
2. Know the disciplines and sub groups in aerospace engineering.
3. Know the global and Indian aerospace activities and future challenges.

Textbook:
1. Anderson, D. F. and Eberhardt, S., Understanding Flight, 2nd ed., McGraw-Hill, 2009.
2. Anderson, J. D., Introduction to Flight, 7th ed., McGraw-Hill, 2011.
3. Szebehely, V. G. and Mark, H., Adventures in Celestial Mechanics, 2nd ed., Wiley, 1998.
4. Turner, M. J. L., Rocket and Spacecraft Propulsion: Principles, Practice and New Developments, 3rd ed., Springer, 2009.

References:
1. Stengel, R. F., Flight Dynamics, Princeton University Press, 2004.
2. Roskam, J., Airplane Flight Dynamics and Automatic Flight Controls, DAR Corporation, 1995.
3. Nelson, R. C., Flight Stability and Automatic Control, McGraw Hill International, 1990.
4. Etkin, B. and Duffy, L. D., Dynamics of Flight: stability and control, John Wiley, 1995.
5. Moir I. and Seabridge A., Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration, 3rd ed., John Wiley & Sons, 2011.
6. Kermode, A.C, Mechanics of Flight, English Book Store, 1982.
7. Van Sickle Neil, D, Modern Airmanship Van Nostr and Reinhol, 1985.
8. Megson T.H. Aircraft Structures for Engineering Student‘s II Edition, Edward Arnold, Kent, 1990

Web References:
1.https://nptel.ac.in/courses/101101001/
2. https://www.youtube.com/watch?v=D-XZjtsi6e0

COURSE		CREDITS			MARKS	
NAME	AERO-THERMODYNAMICS	L	T	P	CIE	SEE
CODE	19AE3DC ATD	3	0	0	50	50

Course objectives:
To introduce fundamental concepts in thermodynamics concepts and laws in application to aerospace systems.

Course pre - requisite: Engineering Mathematics, Engineering Physics, Engineering Chemistry

Unit-1 **9 hours**

Fundamental concepts and definitions: Thermodynamics definition and scope; Microscopic and Macroscopic approaches; Some practical applications of engineering thermodynamic systems; Characteristics of system boundary and control surface – examples; Thermodynamic properties; definition and modules, intensive and extensive properties; Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium, Zeroth law of thermodynamics, Temperature concepts, scales, fixed points and measurements.

Work and heat: Mechanics-definition of work and its limitations; Thermodynamic definition of work; examples, sign convention. Displacement work - as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams; Shaft work; Electrical work. Other types of work.

Unit-2 **9 hours**

First law of thermodynamics: Joules experiments, equivalence of heat and work; Statement of the first law of thermodynamics; Extension of the first law to non - cyclic processes, energy, energy as a property, modes of energy, pure substance; Definition, two-property rule; Specific heat at constant volume, enthalpy, specific heat at constant pressure; Extension of the first law to control volume; Steady state-steady flow energy equation, important applications, analysis of unsteady processes such as film and evacuation of vessels with and without heat transfer.

Unit-3 **9 hours**

Second law of thermodynamics: Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle; Thermal reservoir; Direct heat engine; schematic representation and efficiency; Devices converting work to heat in a thermodynamic cycle; Reversed heat engine, schematic representation, coefficients of performance; Kelvin - Planck statement of the second law of thermodynamics; PMM I and PMM II, Clausius statement of second law of thermodynamics; Equivalence of the two statements; Reversible and Irreversible processes; Factors that make a process irreversible, reversible heat engines, Carnot cycle, Carnot principles.

Entropy: Clasius inequality; Statement, proof, application to a reversible cycle; Entropy; definition, a property, change of entropy, principle of increase in entropy, entropy as a quantitative test for irreversibility, calculation of entropy using T-ds relations, entropy as a coordinate; Available and unavailable energy.

Unit-4 **9 hours**

Pure substances & ideal gases: Mixture of ideal gases and real gases, ideal gas equation, compressibility factor use of charts. PT and P-V diagrams, triple point and critical points. Sub-cooled liquid, Saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams.

Thermodynamic relations: Maxwell's equations, T-ds relations, ratio of heat capacities, evaluation of thermodynamic properties from an equation of state.

Unit-5 **9 hours**

Gas power cycles: Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, P-V & T-S diagram, calculation of efficiency; Carnot vapour power cycle; Simple Rankine cycle -analysis and performance; Reheat and regenerative cycles; Brayton cycle.

Aero - thermodynamics: Introduction; Aero – thermodynamics for space vehicles; Thermal surface effects; Flight environment.

Course outcomes:
After studying this course, students will be able to:
1. Understand and the thermodynamic laws and their applications.
2. Familiarize with gas power cycles, gas mixture and chemical reactions.
3. Appreciate the need for studying the aero-thermodynamics.

Textbook:
1. Cengel, Y. A. and Boles, M. A., Thermodynamics: An Engineering Approach, 8th ed., McGraw-Hill, 2014.
2. Nag, P. K., Engineering Thermodynamics, 4rd ed., Tata McGraw-Hill, 2005.
3. Sonntag, R.E., Borgnakke, C. and Van Wylen, G.J. Fundamentals of Thermodynamics, 6th ed., Wiley, 2002.

References:
1. Rogers, G. F. C. and Mayhew, Y. R., Engineering Thermodynamics: work and heat transfer, 4th ed., Longman, 1992.
2. Hill, P.G. and Peterson, C.R., 1992. Mechanics and Thermodynamics of Propulsion, Pearson Education, 2009.
3. Moran, M. J., Shapiro, H. N., Boettner, D. D., and Bailey, M. B., Principles of Engineering Thermodynamics (SI Version), 8th ed., Wiley, 2015.
4. Spalding, D. B. and Cole, E. H., Engineering Thermodynamics, 3rd ed., Edward Arnold, 1973.
5. Jones, J. B. and Dugan, R. E., Engineering Thermodynamics, Prentice Hall, 1996.
6. Rayner Joel, Basic Engineering Thermodynamics, 5thed., Addison Wesley, New York, 1996.
7. Balmer, R. T., Modern Engineering Thermodynamics, Academic Press, 2011.
8. Holman, J. P., Thermodynamics, 4thed. Tata McGraw Hill, New Delhi, 1998
9. Rathakrishnan. E, Fundamentals of Engineering Thermodynamics, Prentice –Hall, India, 2000.
10. Hirschel, E.H., Basics of Aerothermodynamics, 2005.

Web References:
1. https://nptel.ac.in/courses/112104113/
2. https://nptel.ac.in/courses/101104063/
3. https://nptel.ac.in/courses/112106133/

COURSE		CREDITS			MARKS	
NAME	AERO-FLUID MECHANICS	L	T	P	CIE	SEE
CODE	19AE3DC AFM	3	0	1	50	50

Course objectives:
1. To introduce the concept of fluid and their properties.
2. To make the student understand the fluid laws and the flows.

Course pre-requisite: Vector Calculus, Engineering Mechanics

Unit-1 **9 hours**

Fluid properties: Brief history of fluid mechanics; Concept of a Fluid- types of fluids and fluid as a continuum; Fluid properties - mass density, specific weight, specific gravity, Newton's law of viscosity - dynamic viscosity, kinematic viscosity, compressibility and vapor pressure, surface tension, capillarity; Stoke's theorem.

Fluid statics: Pressure distribution in a static fluid; Pressure and its measurement; Hydrostatic forces on plane and curved surfaces; Buoyancy and stability of floating and submerged bodies; Metacentric height; Illustration examples.

Unit-2 **9 hours**

Fluid kinematics: Methods of describing fluid motion; Types of fluid flow, Stream, path and streak lines; Motion of a fluid particle; Velocity potential function and stream function; Kinematics of fluid motion and the constitutive equations, Differential form of mass conservation equation and applications, Continuity equation in 3 dimensions; Numerical problems.

Governing equations of fluid kinetics: Introduction to Integral (global) and Differential forms, Derivation of Differential form of conservation equations (momentum and energy) - Euler, Navier-Stokes and Energy equations; Applications.

Unit-3 **9 hours**

Analysis of fluid dynamic systems: Equations of motion along a stream line, Euler's and Bernoulli's equation of motion for ideal and real fluids; Application of Bernoulli's equation – Direct (Pitot tube), through pipe (Venture, Nozzle and Orifice meter) and open channel (Sluice gate, rectangular and triangular notch) for fluid flow measurements; Numerical problems.

Analysis of dimensions and similarities: Dimensions of physical quantities; Dimensional homogeneity; Methods of dimensional analysis; Model analysis, types of similarity and similitude. Buckingham Pi Theorem, Dimensionless numbers. Model law; Numerical problems.

Unit-4 **9 hours**

Viscous flow: Laminar and turbulent flow, Hagen - Poiseuille flow in circular pipes, Development of flow in pipes, Pipe friction, Darcy-Weisbach equation and Chezy's formula, Pipe losses - Major and Minor losses - Problems of parallel, Series and branched pipes.

Flow past immersed bodies: Introduction to boundary layer, boundary layer thickness, Karman's integral momentum theory, drag on a flat plate for laminar and turbulent flow, Drag on immersed bodies. Expression for drag and lift. Kutta – Joukowsky theorem; Numerical problems.

Unit-5 **9 hours**

Potential flow: Flow past closed-body shapes, Fundamentals of aero foil theory, Numerical problems.

Compressible flow: Steady, one-dimensional gas dynamics, Propagation of pressure waves in a compressible medium, velocity of sound, Mach number, Mach cone, Stagnation properties, Bernoulli's equations for isentropic flow, normal shock waves, Numerical Problem.

Course outcomes:
After studying this course, students will be able to:
1. Understand and apply conservation laws and dimensional analysis to fluid flow problems.
2. Familiarize with flow through closed conduits and gas flow.

Textbook:
1. Munson, B.R., Okiishi, T.H., Huebsch, W.W. and Rothmayer, A.P., Fluid mechanics. Singapore: Wiley, 2013.
2. White, F.M., Fluid mechanics, 7th ed., McGraw Hill Publications, 2011.

References:
1. Yunus, A.C., Fluid Mechanics: Fundamentals and Applications (SI Units). Tata McGraw Hill Ed. Private Limited, 2010.
2. SomS.K., BiswasG., Introduction to Fluid Mechanics and Fluid Machines, 3rd ed., McGraw Hill Publications, 2011.
3. Fox and Macdonald, Introduction to Fluid Mechanics by, 8th ed., Wiley India, 2013.
4. Kumar, K.L., Fluid Mechanics, 2nd ed., Tata McGraw-Hill, 2000.
5. Anderson, John D. Jr., Computational Fluid Dynamics the Basics with Applications, McGraw-Hill International Editions: Mechanical Engineering), 1995.

Web References:
1.http://nptel.ac.in/courses/112104118/
2. https://nptel.ac.in/courses/112105183/

AERO-FLUID MECHANICS LABORATORY

Course objectives:
To demonstrate the fluid mechanics laws using various flow meters and flow visualization techniques.

Course pre - requisite: Aero - Fluid Mechanics

Unit-A **FLUID PROPERITY STUDIES** **10 hours**

1. Determination of viscosity using Red wood viscometer.
2. Determination of surface tension by using capillary tube.
3. Verification of Bernoulli's theorem.
4. Study of hydrostatics.
5. Stability of floating bodies

Unit-B **FLOW DETERMINATION STUDIES** **20 hours**

1. Determination of type of flow by Reynolds apparatus.
2. Velocity measurement using Pitot static tube.
3. Calibration of flow measuring devices.
4. Determination of coefficient of discharge of orifice meter, nozzle, Venturi-meter and V-notch.

5. Major loss due to friction in pipe flow.
6. Minor losses due to pipe fittings in pipes.
7. Flow visualization using smoke, dye and Hele Shaw apparatus.
8. Aerodynamic studies on isolated airfoil in wind tunnel.

Course outcomes:

After studying this course, students will be able to:

1. To gain the knowledge of various flow meters and the concept of fluid mechanics.
2. Gain knowledge on different forms of energy of flowing fluids.

References:

1. Laboratory manual

COURSE		CREDITS			MARKS	
NAME	MATERIALS FOR AEROSPACE ENGINEERING	L	T	P	CIE	SEE
CODE	19AE3DC MAE	3	0	0	50	50

Course objectives:
To introduce the materials for aerospace with their behaviors and characteristics.

Course pre - requisite: Elements of Mechanical Engineering

Unit-1 **9 hours**

Engineering materials: Physical metallurgy; Materials and their classification -titanium, nickel, magnesium and aluminium alloys, intermetallics, steels, cast aluminium alloys, ceramics, production of semi- fabricated forms, plastics and rubber, polymers, shape memory alloys; Introduction to FRP, glass and carbon composites; fibers and resins andtheir applications; Materials used for aircraft components; Corrosion resistant materials used in aircraft. Use of materials high temperature materials in thermal protection systems of aerospace vehicles; Concept of stealth materials; Emerging trends in aerospace materials.

Unit-2 **9 hours**

Non-ferrous materials in aircraft construction: Aluminium and its alloys: Types and identification; Properties - Castings – Heat treatment processes - Surface treatments. Magnesium and its alloys: Cast and Wrought alloys – Aircraft application, features specification, fabrication problems, Special treatments. Titanium and its alloys: Applications, machining, forming, welding and heat treatment, Copper Alloys. Wood and fabric in aircraft construction: Glues, Use of glass, plastics & rubber in aircraft.

Unit-3 **9 hours**

Ferrous materials in aircraft construction: Steels: Plain and low carbon steels, various low alloy steels, aircraft steel specifications, corrosion and heat resistant steels, structural applications. Maraging Steels: Properties and applications; Super Alloys: use - Nickel base - Cobalt base - Iron base - forging and casting of super and Indigenisedalloys - welding, Heat treatment.

Unit-4 **9 hours**

Ceramics, composites and stealth materials: Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes involved in metal matrix composites, polymer composites, applications in aerospace vehicle design; Application of composite and smart materials; Method of achieving stealth and radar absorbing materials.

Unit-5 **9 hours**

Behavior and characterization of engineering materials: Linear and non-linear elastic properties; Mechanism of elastic and inelastic action - Yielding, strain hardening, fracture, Elastic after effect; Bauchinger's effect, notch effect; Testing and flaw detection of material and components. Fibers and resins – characteristics; Material characterization at high temperature; Characterization of radar absorbing materials; Knowledge of various testing machines.

Course outcomes:
After studying this course, students will be able to:
1. Understand the different materials and their properties.
2. Characteristics and applications of these materials in aerospace.

Textbook:
1. Mouritz, Adrian P. Introduction to aerospace materials. Elsevier, 2012.
2. William D. Callister Jr., Materials Science and Engineering - An Introduction, Wiley India Pvt. Ltd.

References:
1. H Buhl, Advanced Aerospace Materials, Springer, Berlin, 1992.
2. Van Vlack, L.H., Material Science for Engineers, 6th ed., Addison Wesley, 1985.
3. Titterton, G., Aircraft Materials and Processes, 5th ed., Pitman Publishing Co., 1995.
4. Martin, J.W., Engineering Materials, Their Properties, and Applications, Wykedham Publications (London) Ltd., 1987.
5. Krishnadas Nair, C.G., Handbook of Aircraft Materials, Interline Publishing, 1993.
6. Balram Gupta, Aerospace Materials, Vol.I, Vol. II and Vol. III, S.Chand & Company Ltd., 1996.
7. Parker E. R., Materials for Missiles and Space, McGraw-Hill Inc., 1963.
8. Hill E. T., The Materials of Aircraft Construction, Pitman London.
9. Campbell Jr, Flake C. Manufacturing technology for aerospace structural materials. Elsevier, 2011.

Web References:
1.https://nptel.ac.in/courses/101106038/
2. https://nptel.ac.in/courses/101104010/

COURSE		CREDITS			MARKS	
NAME	MANUFACTURING TECHNOLOGYFOR AEROSPACE ENGINEERING	L	T	P	CIE	SEE
CODE	19AE3DC MTA	3	0	1	50	50

Course outcomes:
1. To introduce the concepts of manufacturing technology.
2. To introduce the methodology of aerospace component manufacturing.

Course pre - requisite: Elements of Mechanical Engineering, Engineering Physics.

Unit-1 **9 hours**

Introduction: Introduction to manufacturing and types of manufacturing processes, Classification, selection and application of manufacturing processes.

Casting: Metal casting, Sand casting: Patterns – types, materials and allowances. Moulding–types, moulding sand, role of gating system and cores and core making. Special casting Process – shell, investment, die, centrifugal and permanent mould casting, casting defects and their remedy. Application to aerospace components.

Unit-2 **9 hours**

Mechanical working of metals: Hot and cold working- rolling, forging, wire drawing; Extrusion: types –forward-backward and tube extrusion. Sheet metal operations-blanking - blank size calculation, draw ratio, drawing force, piercing, punching, trimming, stretch forming, shearing, bending, Simple problems - bending force calculation, tube forming; Embossing and coining, types of dies: progressive, compound and combination dies, defects in forming; Joining techniques in engineering/aerospace applications – fusion and solid state welding process and equipment.

Unit-3 **9 hours**

Metal cutting and surface finishing process: Orthogonal and oblique cutting; Classification of cutting tools - single, multipoint; Cutting tool materials - tool wear and tool life and machinability; Cutting fluids; Machining operations- boring, jig boring and broaching. Grinding process, various types of grinding; Grinding wheel - types - selection of cutting speed and work speed, dressing and truing. Fine finishing - lapping, buffing, honing, and super finishing.

Non-traditional machining processes: Principle; equipment, operation and applications of ultrasonic machining; Abrasive water jet machining, Chemical and electro chemical machining, Electro-discharge machining, Laser beam machining, Plasma arc machining.

Unit-4 **9 hours**

Numerical control manufacturing: Nomenclature of NC machines, Types of NC machines, CNC and DNC concept; Evolution of CNC technology, principles, features, advantages and applications; Classification of CNC machines – turning center, machining center and grinding machine. Programming for NC machines.

Rapid prototyping: Development of RP systems, Rapid tooling and manufacturing- Principle and application for aerospace; file format; on demand manufacturing – direct material deposition and shape deposition manufacturing**.**

Unit-5 **9 hours**

Gear manufacturing: Gear manufacturing processes: Extrusion, stamping, and powder metallurgy. Gear machining: forming, gear generating process – shaping and hobbing.

Aerospace manufacturing principle and processes: Additive Manufacturing, Component manufacturing -Raw materials; Jet engine manufacturing process - fan blade, compressor disc, compressor blades, combustion chamber, turbine disc and blades, exhaust system and final assembly; Assembly line - Fundamentals of building Aircraft, Major aircraft materials and its classification, Composite materials and its manufacturing processes, Quality control and assurance.

Course outcomes:
After studying this course, students will be able to:
1. Understand the concepts of casting technology.
2. Mechanical working of metals.
3. Metal cutting, machining and surface finishing processes.
4. CNC machining and RP based manufacturing.
5. Gear and aero engine manufacturing process.

Textbook:
1. Beddoes, J. and Bibby, M. J., Principles of Metal Manufacturing Processes, Butterworth-Heinemann, 1999.
2. Rao, P.N., Manufacturing Technology, Vol I and II, 2nd ed., Tata McGraw Hill Publishing Co., 2009.
3. Moxon, Julian. How Jet Engines Are Made. Threshold Books, 1985.
4. Radhakrishnan P, Computer Numerical Control Machines, New Central Book Agency, 2002.
5. Rafiq I. Noorani, Rapid Prototyping, Principles and Applications, Wiley & Sons, 2006.

References:
1. Ghosh, A. and Mallik, A. K., Manufacturing Science, Affiliated East West Press, 2010.
2. Abbaschian, R., Abbaschian, L., and Reed-Hill, R. E., Physical Metallurgy Principles, 4thed.,Cengage Learning, 2008.
3. Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises (2008).
4. Groover, M. P., Fundamentals of Modern Manufacturing: Materials, Processes, and Systems,5thed., Wiley-India, 2012.
5. Hajra Choudhary, S. K. and Hajra Choudhary, A. K., Elements of Manufacturing Technology, Vol II, Media Publishers, Bombay, 2007
6. Ott, James. Jets: Airliners of the Golden Age. Pyramid Media Group, 1990.
7. Peace, P. Jet Engine Manual. State Mutual Book & Periodical Service, 1989.
8. Kalpakjian, S. and Schmidt, S. R., Manufacturing Processes for Engineering Materials, 5thed., Pearson Education, 2007.

Web References:
1.https://nptel.ac.in/courses/112104195/
2. https://nptel.ac.in/courses/112101005/10

AERO –MANUFACTURINGTECHNOLOGYLABORATORY

Course objectives:
To expose hands-on training to the students on various machines like lathe, shaper, slotter, milling, gear hobbing, grinding, CNC and RP machines.

Course pre - requisite: Manufacturing Technology for Aerospace Engineering

One model each involving
c) Lathe milling and shaping operations

d) CNC operations (demo model)
e) RP operations (demo model)

Unit-A MACHINES FOR MANUFACTURING 15 hours

Preparation of one model on lathe involving plane turning, taper turning, step turning, facing, convex shape turning, external thread cutting: V-thread and square thread.

Unit-B FIBRICATION AND MINI PROJECTS 15 hours

1. Cutting of V-groove using a shaper, cutting of spur gear teeth, Helical gear using milling machine.
2. A demonstration of simple CNC operation on work piece.
3. A demonstration of simple aero model manufacturing on RP machine.

Course outcomes:
After studying this course, students will be able to:
1. Understand the basics of machines for manufacturing.
2. Understand and apply the concept of production types.

References:
1. Laboratory manual

COURSE		CREDITS			MARKS	
NAME	COMPUTER AIDED TOOLS FOR AEROSPACE ENGINEERING	L	T	P	CIE	SEE
CODE	19AE3DC CTA	1	0	1	50	50

Course objectives:
To give an overview of computer tools and introduce them for aerospace engineering problem solving.

Course pre - requisite: Nil.

Unit-1 **3 hours**

Aerospace articles using processing tools: Introduction to engineering articles- brochures, catalogs, essays/manuscripts, papers, books, banners, posters, loyalty cards, editor note, key note, audio, tapes, video tapes, notes and CDs, Comparison of current generation word processing, spread sheets, presentation and publishing tools. MS office, LATEX tools and their file types, Use of standard templates and customizing for writing, drawing of figures, tables and charts, presentation preparation in MS office. Design of brochure, portfolio and display posters for aerospace application. Grammar checking and plagiarism using Grammarly. Technical communication through Skype, Operating systems: Windows, UNIX and LINUX, Case studies.

Unit-2 **3 hours**

Programming tools: Concepts of script and graphical programming, Computing with excel macros, Current generation programming tools for solving aerospace problems, Introduction and comparison of salient features of C++, Math CAD, MATLAB, Minitab, R programming and Python. Graphical programming using Simulink and Lab View, Case studies.

Unit-3 **3 hours**

Drawing and layout tools: Need for drawing and layout, Transformations, projections and dimensioning, Drawing of orthographic and isometric views. Layout - process and plant systems, Comparison of salient features of current generation programming drawing tools, Case study- simple component drawing in Auto CAD.

Unit-4 **3 hours**

Geometry modeling and scanning tools: Introduction to product development techniques – solid modeling and clay modeling. Reverse engineering -geometry scanning using measurement machines- Ferro arm and coordinate measurement tools. Drawing and image scanning tools. Surface generation using commercial software, geometric modeling kernels, Data exchange standards, Comparison of current generation commercial CAD software in aerospace industry, Modeling concepts, Case studies.

Unit-5 **3 hours**

Analysis tools: Assembly modeling, Introduction to computer aided analysis; geometry interferences of positions and orientation tolerance analysis, mass property calculations. Motion, tool path, structural, thermal and fluid simulations. Comparison salient features of current generation commercial CAE, CFD and CAM software in aerospace industry, Case studies.

Course outcomes:
After studying this course, students will be able to:
1. Understand the computer tools, their need and salient features.
2. Select the most appropriate tools for aerospace application.

Textbook:
1. Becker, H.S., Writing for social scientists: How to start and finish your thesis, book, or article. University of Chicago Press, 2008.
2. Shinn, E. Christine. Microsoft Office XP/2001 for Teachers: A Tutorial for Windows and MacIntosh. Prentice-Hall, Inc., 2002.
3. Zeid I., Mastering CAD CAM, Tata McGraw-Hill Publishing Co.2007.

References:
1. Belcher W. L., Writing Your Journal Article in Twelve Weeks- A Guide to Academic Publishing Success, SAGE Publications, Inc, 2009
2. Catherine A. Ingle, Reverse Engineering, Tata Mc Graw Hill Publication, 1994
3.Chris McMahon and Jimmie Browne, CAD/CAM Principles-Practice and Manufacturing management, Second Edition, Pearson Education, 1999.
4. David D. Bedworth, Mark R. Henderson, Philp M. Wolfe, Computer Integrated Design and manufacturing, Mc Graw Hill International series, 1991
5. Donald R. Honra, Co-ordinate measurement and reverse Engineering, American Gear Manufacturers Association.
6. ZeidI. and SivasubramanianR., CAD/CAM Theory and Practice, Revised First special Indian Edition, Tata Mc Graw Hill Publication, 2007

Web References:
1.https://www.youtube.com/watch?v=gY0sEokk2h0&list=PLLBUgWXdTBDi-E--rwBujaNkTejLNI6ap/

COMPUTER AIDED TOOLS FOR AEROSPACE ENGINEERINGLABORATORY

Course objectives:
To train the students to use computer aided tools for aerospace engineering.

One exercise involving

Unit-A **15 hours**

1. A sample aerospace article writing, poster and presentation using MS office tools.
2. Programming for aerospace computation using MATLAB.
3. 2D drawing of simple component using AutoCAD tool.
4. 3D solid modeling of simple components using Solid Works and assembly.

Unit-B **15 hours**

1. Motion simulation.
2. Tool path generation.
3. A cantilever beam static analysis.
4. A thermal - heat conduction problem.
5. A flow over a cavity simulation.

Course outcomes:
After studying this course, students will be able to:
1. Use of the computation tools for aerospace problem solving.

References:
1. Laboratory manual

IV Semester Syllabus

COURSE		CREDITS			MARKS	
NAME	ENGINEERING MATHEMATICS - 4	L	T	P	CIE	SEE
CODE	19MA4BS EM4	3	1	0	50	50

Course objectives:
1. To make prepare students with adequate knowledge in Probability and Statistics, Complex Analysis and develop computational skills using efficient numerical methods for problems in science and engineering.

Course pre- requisite: Complex numbers, multivariate calculus and basic concepts of Statistics and Probability.

Unit-1 **10 hours**

Statistics and probability: Curve fitting – Principle of least squares, fitting a straight line, fitting of a parabola, fitting of exponential curve of the form $y = ab^x$. Correlation and regression. Probability distributions: Discrete distribution - Poisson distribution. Continuous distribution- Normal distribution.

Unit-2 **9 hours**

Joint probability distributions: Discrete random variables, Mathematical expectations, Covariance and Correlation.

Markov chain: Markov Chain, Probability vectors, stochastic matrices, fixed point vector, regular stochastic matrices. Higher transition probabilities, stationary distribution of regular Markov chain.

Unit-3 **9 hours**

Numerical solution of partial differential equations: Finite-Difference formulas to partial derivatives. Applications: Solution of one-dimensional heat equation using 2-level formula and Schmidt explicit formula and Crank-Nicolson two-level implicit formula. Solution of one-dimensional wave equation using explicit three level formula and implicit scheme.

Unit-4 **10 hours**

Complex analysis – 1: Functions of a complex variable, limits, continuity and differentiability of a complex valued function, Analytic functions, properties of analytic functions, Cauchy-Riemann equations in Cartesian and polar form, construction of analytic functions by Milne-Thomson method.

Conformal mapping: $w = z^2$ and $w = z + \frac{a^2}{z}\left(z \neq 0\right)$. Bilinear transformations

Unit-5 **10 hours**

Complex analysis – 2: Complex integration: Line integral, Problems on line integral, Cauchy's theorem, Cauchy's integral formula.Complex series: Taylor's, Maclaurin's and Laurent's series (without proof)-examples.Zeros, Poles and Residues, Cauchy's residue theorem (without proof)-examples.

Course outcomes:
After studying this course, students will be able to:
1. Demonstrate an understanding of concepts of statistical analysis and probability distributions.
2. Apply Numerical techniques to solve partial differential equations arising in engineering.
3. Demonstrate an understanding of analytic functions and their application to evaluate integrals.

Textbook:

1. Numerical Methods for Engineering, R. P. Kanale and S. C. Chapra, 6th edition, McGraw Hill, Publishers
2. Ramana B. V., Higher Engineering Mathematics, Tata McGraw Hill, 2007.

References:

1. James G., Advanced Modern Engineering Mathematics, Pearson Education, 3rd ed., 2004.
2. Grewal B. S., Higher Engineering Mathematics, Khanna Publishers, 43rd edition, 2014.

Web References:

1.https://nptel.ac.in/courses/111105090/ (Probability & statistics-Joint distribution, testing of hypothesis)
2.https://nptel.ac.in/courses/111103070/ (Complex Analysis - Analytic functions, Mobius transformation & Residue theorem)
3. https://nptel.ac.in/courses/111107056/ (Complex Analysis - Complex integration, conformal mapping)

COURSE		CREDITS			MARKS	
NAME	AIRCRAFT SYSTEMS, AVIONICS AND INSTRUMENTATION	L	T	P	CIE	SEE
CODE	19AE4DC AAI	4	0	0	50	50

Course objectives:
To introduce the hydraulic, pneumatic and electronic systems, and instruments used in an aerospace vehicles.

Course pre-requisite: Introduction to Aerospace Engineering

Unit-1 **9 hours**

Aircraft systems: Hydraulic systems; Study of typical workable systems – components; Hydraulic systems controllers; Modes of operation; Pneumatic systems – Working principles and typical pneumatic power system; Brake system – components; Landing gear systems – classification, shock absorbers and retractive mechanism.

Unit-2 **9 hours**

Airplane control systems: Conventional Systems – power assisted and fully powered flight controls – power actuated systems; Engine control systems – push pull rod system and operating principles; Modern control systems – digital fly by wire systems andauto pilot system; Active control technology. Maneuvering characteristics augmentation system.

Unit-3 **9 hours**

Engine systems: Fuel systems; components; multi-engine fuel systems, lubricating systems, starting and ignition systems of Pistonand Jet engines,Effect of bird hits and emergency landings.

Unit-4 **9 hours**

Air-conditioning and pressurizing system: Basic air cycle systems – vapour cycle systems; Boot-strap air cycle system; Evaporative vapour cycle systems; Evaporation air cycle systems; Oxygen systems; Fire protection systems; Deicing and anti-icing system.

Unit-5 **9 hours**

Aerospace avionics: Communication and tracking, Guidance, navigation and control, display and control, flight-control system, fuel systems, collision-avoidance systems, flight recorders, weather systems, payload operation systems and system management.

Aircraft instruments: Principles and operation of air pressure-dependent sensors, radar altimeters, radio sensors and propulsion sensors. Flight and navigation instruments – accelerometers, air data instruments-airspeed, altitude, temperature, vertical speed and angle of attack measurement. Mach meters, Altimeters and Gyroscopic instruments– gyro system, gyroscope, gyro direction indicator, rate gyro-rate of turn and slip indicator; Study of various types of engine instruments – pressure, oil and exhaust gas temperature, RPM tachometers, manifold pressure- EPR, torque, temperature measurement, fuel flow, fuel quantity, engine vibration monitoring instruments.

Course outcomes:
After studying this course, students will be able to:
1. Understand the basic aircraft systems
2. Know the basic controlling units and the instruments of an aerospace vehicle.

Textbook:

1. Mekinley, J.L. and BentR.D., Aircraft Power Plants, McGraw Hill 1993.
2. Pallet, E.H.J., Aircraft Instruments & Principles, Pitman & Co 1993.
3. NagabhushanaS. andPrabhuN.,Principles of Modern Avionics, I K International Publishing House, 2018

References:

1. Teager, S., Gas Turbine technology, McGraw Hill 1997.
2. Mckinley, J.L. and Bent R.D. Aircraft Maintenance & Repair, McGraw Hill, 1993.
3. Handbooks of Airframe and Powerplant Mechanics, US dept. ofTransportation, Federal, Aviation Administration, The English Book Store, NewDelhi, 1995.
4. Murthy, D.V.S., Transducers and Measurements, McGraw-Hill, 1995.
5. Doeblin.E.O, Measurement Systems Application and Design, McGraw-Hill, NewYork, 1986.
6. Nagabhushana S. and Sudha L.K., Aircraft Instrumentation and Systems, I K International Publishing House, 2010.
7. Helfrick A., Principles of avionics, Avionics Communications, 2010.

Web References:

1. https://nptel.ac.in/courses/101106042/2
2. https://nptel.ac.in/courses/101105059/

COURSE		CREDITS			MARKS	
NAME	AERO - HEAT AND MASS TRANSFER	L	T	P	CIE	SEE
CODE	19AE4DC AHT	3	0	0	50	50

Course objectives:
1. To introduce the various modes of heat transfer.
2. To solve the heat transfer problem related to aerospace engineering.

Course pre - requisite: Aero -Thermodynamics

Unit-1 **9 hours**

Fundamentals: Different modes of heat transfer and mass and momentum transfer, elements of mass diffusion and boundary layer theory. Mass transfer definition and terms used in mass transfer analysis, Ficks First law of diffusion (no numerical).

Unit-2 **9 hours**

Conduction: Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems. Effect of variation of thermal conductivity on heat transfer in solids – Heat transfer problems in infinite and semi-infinite solids – Extended surfaces.

One dimensional transient heat conduction: Systems with negligible internal resistance, Significance of Biot and Fourier Numbers, Chart solutions of transient conduction systems.

Unit-3 **9 hours**

Convection: Concepts of continuity, momentum and energy equations. Dimensional analysis-Buckingham's Pi theorem - Application for developing non-dimensional correlation for convective heat transfer.

Free convection: Development of hydrodynamic and thermal boundary layer along a vertical plate, Use of empirical relations for Vertical plates and pipes.

Forced convection: External flows, concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for flat plates and cylinders. Internal flows, concepts ofhydrodynamic and thermal entry lengths, use of empirical correlations for horizontalpipe flow and annulus flow.

Unit-4 **9 hours**

Radiation: Introduction to physical mechanism - Radiation properties - Radiation shape factors - Heat exchange between non-black bodies - Radiation shields.

Heat exchangers: Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems.

Unit-5 **9 hours**

Boiling and condensation: Introduction to boiling, pool boiling, Bubble growth mechanisms, Nucleate pool and pool film boiling, Critical Heat Flux, Heat transfer beyond the critical point, Film wise and dropwisecondensation, heat pipes, entrainment, wicking and boiling limitations.

Mass transfer: Introduction, Ficks law, Species conservation equation, Introduction to convective and diffusive mass transfer.

Heat transfer problems in aerospace engineering: Heat transfer problems in gas turbine combustion chambers; Rocket thrust chambers; Aerodynamic heating; Ablative heat transfer.

Course outcomes:
After studying this course, students will be able to:
1. Familiarize on the various modes of heat transfer.
2. Solve the heat transfer problem related to aerospace engineering.

Textbook:
1. Bergman, T. L., Lavine, A. S., Incropera, F. P., and DeWitt, D. P., Fundamentals of Heat and Mass Transfer, 7th ed., John Wiley, 2011.
2.Cengel, Y. A. and Ghajar, A. J., Heat and Mass Transfer: Fundamentals and Applications, 5th ed., Tata McGraw-Hill, 2014.
3. Sachdeva, S.C., Fundamentals of Engineering Heat and Mass Transfer, Wiley Eastern Ltd., 1981.

Data Book:
Kothandaraman, C. P. and Subramanyan, S., Heat and Mass Transfer Data Book, 8th ed., New Age International Pub. (2014).

References:
1. Lienhard, J. H., A Heat Transfer Text Book, Prentice Hall Inc., 1981.
2. Holman, J. P., Heat Transfer, 10th ed., Tata McGraw-Hill, 2010.
3. Nag, P. K., Heat transfer, Tata McGraw Hill, 2002
4. Sukhatme, Suhas P. A textbook on heat transfer. Universities Press, 2005.
5. Ozisik, Heat transfer-A basic approach, Tata McGraw Hill 2002

Web References:
1.https://nptel.ac.in/courses/101104063/
2. https://nptel.ac.in/courses/101103003/37

COURSE		CREDITS			MARKS	
NAME	BASIC AERODYNAMICS	L	T	P	CIE	SEE
CODE	19AE4DC BAD	3	0	1	50	50

Course outcomes:
To study incompressible flow over airfoils, wings, and bodies.

Course pre - requisite: Introduction to Aerospace Engineering

Unit-1 **9 hours**

Introductory topics for aerodynamics: Vortex motions – vortex line, vortex tube- vortex sheet – circulation; KelvinandHelmhotz theorem; Biot – Savarts' law – applications; Rankine'svortex; Kutta – Joukowski theorem.

Unit-2 **9 hours**

Airfoil theory: Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, center of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, Generation of lift - starting and bound vortices - Kutta'strailing edge condition – thin airfoil theory- method of singularities – elementsof panel method.

Unit-3 **9 hours**

Theory of propellers: Axial momentum theory; Influence of wake rotation; Blade-element theory; Combined blade element and momentum theories- tip correction; Performance of propellers.

Unit-4 **9 hours**

Wing theory: Flow past finite wings, vortex model of the wing and induced drag; Prandtl'slifting line theory - elliptic wing –influence of taper and twist applied to wings; Effect of sweep back; Delta wings- elements of lifting surface theory.

Unit-5 **9 hours**

Flow past non-lifting bodies and interference effects: Flow past non lifting bodies; Method of singularities; Wing – body interference; Effect of propeller on wings and bodies and tail unit; Flow over airplane as a whole.

Course outcomes:
1. Calculate forces and moments acting on aero foils and wings under idealflow conditions.
2. Determine the aero foil and wing characteristics.
3. Design a propeller and determine aerodynamic interaction effectsbetween different components of aircraft.

Textbook:
1. Houghton, E, L., and Carruthers, N, B., Aerodynamics for EngineeringStudents, Edward Arnold Publishers Ltd., London, 1989.
2. Anderson, J, D., Fundamentals of Aerodynamics, McGraw Hill Book Co. New York, 1985

References:
1. Clancy, L, J., Aerodynamics, Pitman, 1986.
2. Milne, L.H., Thomson, Theoretical Aerodynamics, Dover, 1985.

Web References:
1. https://nptel.ac.in/courses/101106042/2
2. https://nptel.ac.in/courses/101105059/

LABORATORY

Course outcomes:
To expose the students about the lift and drag forces over different bodies.

Course pre - requisite: Introduction to Aerospace Engineering.

Unit-A VISUALIZATION AERODYNAMICS 15 hours

1. Study of flow over bluff bodies by flow visualization technique.
2. Study of flow over streamlined bodies with different angle of attack byflow visualization technique.
3. Study of flow over a tapered finite wing with and without wingtip by flowvisualization technique.
4. Study of flow over an aircraft model by flow visualization technique.
5. Study of flow over a car model by flow visualization technique.

Unit-A ESTIMATION AERODYNAMICS 15 hours

1. Calibration of subsonic wind tunnel
2. Estimation of drag over a smooth cylinder
3. Estimation of drag over a rough cylinder
4. Estimation of drag over a sphere model
5. Estimation of drag over a car model
6. Estimation of drag over a sphere model by force balance method
7. Estimation of drag over a streamlined body by force balance method
8. Comparison of drag.

Course outcomes:
After studying this course, students will be able to understand the fluid flow, pressure distribution and forces on two dimensional and three-dimensional models.

References:
1. Laboratory manual

COURSE		CREDITS			MARKS	
NAME	AERO-SOLID MECHANICS	L	T	P	CIE	SEE
CODE	19AE4DC ASM	3	0	1	50	50

Course objectives:
To familiarize the students with the fundamentals of deformation, stresses, strainsin structural elements.

Prerequisite: Engineering Mathematics – Calculus, Engineering Mechanics - Statics

Unit-1 **9 hours**

Concept of stresses and strains: Brief history of solid mechanics, Concept of stress and strain, Hooke's law - Tension, compression and shear, stress-strain diagram, Poisson's ratio, elastic constants and their relationship, Deformation of simple and compound bars. Thermal stresses in simple and composite bars. Principal plane, principal stress, maximum shearing stress, Uniaxial, biaxial state of stress and Mohr's circle representation for plane stresses.

Unit-2 **9 hours**

Stresses in beams: Types of beams and loads - shear force and bending moment diagrams for cantilevers, simply supported and over hanging beams. Theory of pure bending - Bending stresses in simple and composite beams. Shear stress distribution in beams of different sections.

Unit-3 **9 hours**

Deflection of beams: Slope and deflection of cantilever, simply supported beam by double integrationmethod - Macaulay's method - Moment area method - Castigliano's theorem.

Unit-4 **9 hours**

Torsion of shafts, columns and cylinders: Theory of pure torsion, torsion of circular shafts and composite shafts.Columns and struts: Member subjected to combined bending and axial loads,Euler's theory, Crippling load, Rankine's theory. Cylinders and Shells: Thin cylinder, thin spherical shells under internal pressure - Thick cylinders - Lame'sequation - Shrink fit and compound cylinders.

Unit-5 **9 hours**

Energy methods: Conservative forces, Principle of minimum total potential energy, Strain energy in springs, Strain energy in beams, Strain energy in solids, Applications to trusses, Development of a finite element formulation for trusses, Principle of minimum complementary, Energy theorems, Reciprocity theorems, Saint-Venant’s principle.

Virtual work principles: Introduction, Equilibrium and work fundamentals, Principle of virtual work, Principle of virtual work applied to mechanical systems, Principle of virtual work applied to truss structures. Principle of complementary virtual work, internal virtual work in beams and solids.

Course outcomes:
After studying this course, students will be able to:
1. Know the concepts of stress and strain.
2. Analyze the beam of different cross sections for shear force, bendingmoment, slope and deflection.
3. Understand the concepts of employing energy methods and virtual work principles.

Textbook:
1. Hibbeler, R. C., Mechanics of Materials, 9th ed., Prentice Hall, 2013.
2. Srinath, L. S., Advanced Mechanics of Solids, 2nd ed., Tata McGraw-Hill, 2003.
3. Beer, F. P., Johnston, E. R., and DeWolf, J. T., Mechanics of Materials, 7th ed., McGraw-Hill, 2014.
4. Timoshenko and Young, Elements of Strength of Materials, East-West Press, 5th edition, 2003

References:
1. William A. Nash, Theory and Problems of Strength of Materials, Schaum'soutline series, McGraw Hill International Edition, 3rd Edition, 2007.
2. Srinath, L. S., Advanced Mechanics of Solids, Tata McGraw Hill PublishingCompany Ltd., New Delhi, 2009.
3. PopovE. P., Engineering Mechanics of Solids, 2nd edition,Prentice Hall of India Private Limited, New Delhi, 2009.
4. James M. Gere, Mechanics of Materials, Eighth Edition, Brooks/Cole, USA, 2013.
5. Shigley, J. E.,Applied Mechanics of Materials, International Student Edition,McGraw Hill Koyakusha Limited, 2000.
6. MegsonT.H.G, Introduction to Aircraft Structural Analysis, Elsevier Exclusive Publications, 2nd edition, 2014.

Web References:
1.https://nptel.ac.in/courses/105104160/
2. https://nptel.ac.in/downloads/105106116/
3. https://onlinecourses.nptel.ac.in/noc15_ce02

AERO-SOLID MECHANICS LABORATORY

Course objectives:
To introduce various material testing and metallographic examination techniques for different engineering materials.

Course pre - requisite: Aero - Solid Mechanics

Unit-A MATERIAL TESTING 15 hours

Testing for aerospace metals, nickel and titanium alloys, aluminum, super alloys, ceramic matrix composites, polymer matrix composites, elastomers, plastics and adhesives.

1. Tensile, shear and compression tests using universal testing machine
2. Torsion and bending test
3. Izod and Charpytests
4. Hardness testing – Vicker's, Brinell, Rockwell
5. Fatigue test
6. Spring test
7. Deflection of beams

Unit-B METALLOGRAPHY 15 hours

1. Examination of different engineering materials. Physical identification ofaerospace materials (Preparation ofSpecimen-demo).
2. Heat treatment: Annealing, Normalizing, Hardening and tempering ofsteel. Hardness studies of heat treated samples (Demo).
3. Demo on Non-destructive tests such as: magnetic particle inspection-crack detection, visual testing-dye penetration testing, ultrasonic inspection, eddy current inspectionto study the defects of casted and weldedspecimens.

Course outcomes:
After studying this course, students will be able to:
1. Apply the relations among materials and their properties.
2. Differentiate the formation, properties and significance of the alloys through different experiments.
3. Understand the different types, advantages and applications of various NDT methods

References:
1. Laboratory manual

COURSE		CREDITS			MARKS	
NAME	AEROSPACE DRAWING AND DRAFTING	L	T	P	CIE	SEE
CODE	19AE4DC ADD	2	1	1	50	50

Course objectives:
1. To impart skills in construction of machine and aerospacecomponent and assembly drawing.
2. Totrain the students to read aerospace component and assembly drawing hands on exercises.

Course pre-requisite: Engineering Graphics

Unit-1 **9 hours**

Introduction: Purpose of the drawing industry; Types of drawings -schematics, sketches,charts,block diagrams and graphs; Component andassemblydrawings; Production drawings - detail, assemblyandinstallation.

Dimensioning conventions: Geometric dimensioning, limits, tolerances and fits.

Unit-2 **9 hours**

Components of production drawings: Components in the production drawings- drawing template, isometric and orthographic drawing views, GD&T symbols, dimensionsangle projection, bill of material (BOM)withtheir indication on main drawing;Conventionalrepresentation of materials, surface roughness; Notes, scale, unit and manufacturing or assembly process sheet, reference;Description on theirspecification,convention, indication symbolsand their location within the drawing.

Unit-3 **9 hours**

Machine elements: Terminology, symbolicrepresentationofthread- sectional views of threads; Fasteners- bolt and nut with washer; Keys,riveted joints, pulleysand couplings; Welded joints; bearings, chains and Gears.

Unit-4 **9 hours**

Aerospace vehicles,components and assemblies: Sketchesand layoutof aircrafts, launch vehicles with terminology, and main functions - parachute, hot air balloons, hang glide, glider, drone, blimp, helicopter, gyroplane, propeller plane, small aircraft planes, stunt plane, biplane, seaplane, executive jet, jumbo jet, concorde jet, cargo jet, military jet plane, military transport plane, supersonic aircraft andspace shuttle;Sketchesandlayoutexercises.

Unit-5 **9 hours**

Aerospace blueprint drawings: Reading of aerospace components drawings - air foil and wing; Reading of gas turbine engine, helicopter, aircraft androcket assemblydrawings.Drafting exercises on simplified aerospace vehicles.

Course outcomes:
After studying this course, students will be able to:
1. Understand machine elements and aerospace components by their symbols and notations.
2. Read aerospacevehicle, component and assembly drawings.

Textbook:
1. John, K. C., Textbook of Machine Drawing, PHI Learning, 2009.
2. Narayana, K. L., Kannaiah, P., and Venkata Reddy K., Machine Drawing, 4th ed., New Age International, 2010.

References:
1. Ajeet Singh, Machine Drawing: Includes AutoCAD, 2nd ed., Tata McGraw-Hill, 2012.
2. Junnarkar, N. D., Machine Drawing, Pearson Education, 2007.
3. Bhatt, N. D. and Panchal, V. M., Machine Drawing, 49th ed., Charotar Publishing, 2014.
4. Sidheswar, N., Kanniah, P., and Sastry, V. V. S., Machine Drawing, Tata McGraw-Hill, 2001.
5. Jenkinson L.R., Marchman J.F. - Aircraft Design Projects for Engineering Students, 2003.
6. Moir I. and Seabridge A., Design and Development of Aircraft Systems, Second Edition, 2012.

Web references:
1. https://www.flight-mechanic.com/aircraft-drawings/
2. http://avstop.com/ac/Aviation_Maintenance_Technician_Handbook_General/ch2.html
3. https://www.the-blueprints.com/blueprints/modernplanes/

AEROSPACE DRAWING AND DRAFTING LABORATORY

Course objectives:
To introduce the concept of design of basic aerospace vehicles and theirstructural components using draftingand modeling package.

Course pre - requisite: Aerospace Drawing and Drafting

Unit-A **15 hours**

1. Layout of simple structural components –propeller, hub assembly and engine mounts.
2. Layout of typical wing assembly.
3. Layout of typical fuselage assembly.
4. Layout of landing gear assembly.
5. Layout of UAVassembly.
6. Layout of main rotor blade assembly of helicopter.

Unit-B **15 hours**

1. Three dimensional design and drafting of typical aircraft.
2. Three dimensional design and drafting of rocket.
3. Three dimensional design and drafting of helicopter.
4. Three dimensional design and drafting ofgas turbine engine components.

Course outcomes:
After studying this course, students will be able to:
1. Distinguish drawings of machine and aerospace components
2. Identify assembly drawings either manually or by using standard CAD packages.
3. Practice with standard components and their assembly of aerospace vehicles.

References:
1. Laboratory manual

COURSE		CREDITS			MARKS	
NAME	CONSTITUTION OF INDIA, PROFESSIONAL ETHICS	L	T	P	CIE	SEE
CODE	19IC4HS CPH	1	0	0	50	50

Course objectives:
1. To educate students about the supreme law of the land.
2. To value human dignity and to save the liberties of the people against discriminations.
3. To raise awareness and consciousness of the issues related to the profession and discuss the issue of liability of risks and safety at work place.

Course pre - requisite: Nil.

Unit-1 **3 hours**

Introduction to Indian Constitution: Historical Background of the Indian Constitution. Framing of the Indian constitution: Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India, Fundamental Rights and its limitations. Fundamental Duties and their significance. Directive Principles of State Policy: Importance and its relevance. Case Studies.

Unit-2 **2 hours**

Union Executive and State Executive: The Union Executive – The President and The Vice President, The Prime Minister and The Council of Ministers. The Union Parliament –Lok Sabha & Rajya Sabha. The Supreme Court of India. State Executive – The Governors, The Chief Ministers and The Council of Ministers. The State Legislature – Legislative Assembly and Legislative Council. State High Courts.

Unit-3 **2 hours**

Election Commission of India, Amendments and Emergency Provisions: Election Commission of India – Powers & Functions – Electoral Process in India. Methods of Constitutional Amendments and their Limitations. Important Constitutional Amendments – 42nd, 44th, 61st,74th, 76th, 77th, 86thand 91st.Emergency Provisions, Case studies.

Unit-4 **2 hours**

Special Constitutional Provisions/ Human Rights: Special Constitutional Provisions for Schedule Castes, Schedule Tribes & Other Backward Classes. Women & Children. Case Studies. Human Rights/values – Meaning and Definitions, Legislative Specific Themes in Human Rights and Functions/ Roles of National Human Rights Commission of India. Human Rights(Amendment Act)2006.

Unit-5 **2 hours**

Professional Ethics: Scope and Aims of Engineering Ethics, Responsibilities of Engineers and impediments to responsibilities. Honesty, Integrity and Reliability; Risks – Safety and Liability in Engineering. Case Studies.

Course outcomes:
After studying this course, students will be able to:
1. Understand and explain the significance of Indian Constitution as the Fundamental Law of the Land.
2. Analyse the concepts and ideas of Human Rights.
3:Apply the practice of ethical responsibilities and duties to protect the welfare and safety of the public

Textbook:

1. Merunandan K.B. and B.R. Venkatesh, An Introduction to Constitution of India and Professional Ethics,3rd ed. Meragu Publications, 2011.
2.Phaneesh K. R., Constitution of India &Professional Ethics& Human Rights,10th ed., Sudha Publications, 2016.

References:

1. Singh M. P. (Revised), V.N. Shukla's Constitution of India, 13th ed., Eastern Book Company, Reprint 2019.
2. Martin, W. Mike.,Schinzinger, Roland., Ethics in Engineering, 4th ed., McGraw-Hill Education, 2004.

Web References:

1.https://books.google.co.in/books/about/Constitution_of_India_and_Professional_E.html?id=VcvuVt-d88QCConstitution of India and Professional Ethics, by G.B. Reddy and Mohd Suhaib, I.K. International Publishing House Pvt. Ltd., 2006.
2.http://www.scribd.com/doc/82372282/Indian-Constitution-M-Raja-Ram-2009#scribdIndian Constitution, by M. Raja Ram, New Age International Pvt. Limited, 2009.

Syllabus for V Semester

COURSE		CREDITS			MARKS	
NAME	MACHINES AND MECHANISMS	L	T	P	CIE	SEE
CODE	20AE5DC MAM	3	1	0	50	50

Course objectives: To teach fundamentals of various laws governing rigid bodies and its motions.

1. Basic mechanisms, velocity and acceleration of simple mechanisms
2. Drawing the profile of cams and its analysis
3. Gear train calculations, Gyroscopes
4. Inertia force analysis and flywheels
5. Balancing of rotating and reciprocating masses.

Course pre- requisite: Nil.

Unit-1 **9 hours**

Introduction: Kinematics, Mechanism Terminology, Kinematic Diagrams, Kinematic Inversion, Mobility, Commonly Used Links and Joints, Mechanism- The Four-Bar, Slider-Crank and Special Purpose Mechanisms. Techniques of Mechanism Analysis.

Mechanisms: Quick return motion Mechanisms-Drag link mechanism, Whitworth mechanism and Crank and slotted lever Mechanism. Straight line motion mechanisms Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms -Geneva wheel mechanism and Ratchet and Pawl mechanism. Toggle mechanism, Pantograph, Ackerman steering gear mechanism.

Unit-2 **9 hours**

Position and Displacement Analysis: Position and Displacement, Position Analysis -Graphical and Analytical, Limiting Positions, Complete Cycle, Displacement Diagrams and Coupler Curves, Problems and Case Studies.

Velocity Analysis: Linear Velocity, Velocity of a Link, Relationship Between Linear and Angular Velocities, Relative Velocity, Graphical Velocity Analysis, Velocity Image, Analytical Velocity Analysis, Algebraic Solutions for Common Mechanisms, Instantaneous Center of Rotation - Locating Instant Centers, Instant Center Method for Graphical and Analytical Velocity Analysis, Velocity Curves, Problems and Case Studies.

Acceleration Analysis: Linear Acceleration, Acceleration of a Link, Normal and Tangential Acceleration, Relative Motion, Graphical and Analytical Method for Relative Acceleration Analysis, Algebraic Solutions for Common Mechanisms, Acceleration of a General Point on a Floating Link, Acceleration Image, Coriolis Acceleration, Equivalent Linkages, Acceleration Curves, Problems and Case Studies.

Unit-3 **10 hours**

Design and Kinematic Analysis of Gear Trains: Types of Gears, Spur Gear Terminology, Involute Tooth Profiles, Standard Gears, Relationships of Gears in Mesh, Kinematics of Gears, Spur Gear Selection, Gear Trains, Idler Gears, Planetary Gear Trains, Problems and Case Studies.

Design and Kinematic Analysis of Cams: Types of cams and followers, Prescribed Follower Motion, Follower Motion Schemes, Graphical Disk Cam Profile Design, Pressure Angle, Design Limitations, Analytical Disk Cam Profile Design, Cylindrical Cams, The Geneva Mechanism, Problems and Case Studies.

Unit-4 **9 hours**

Belt and Chain Drives and Screw Mechanisms: Belts, Belt Drive Geometry, Belt Drive Kinematics, Chains Chain Drive Geometry, Chain Drive Kinematics. Screw Mechanisms: Thread Features, Thread Forms, Ball Screws, Lead, Screw Kinematics, Screw Forces and Torques, Differential Screws and Auger Screws. Friction between unlubricated and lubricated surfaces, Problems and Case Study.

Spheric Motion, Gyroscopic and Flywheel Analysis: Gyroscope and its motions Couple, Effect on an Aeroplane, Stability of a four wheel two-wheel vehicle taking a turn. Couple on a disc fixed rigidle at an angle to a rotating shaft. Speed Fluctuation in Flywheels, Problems and Case Study.

Unit-5 **8 hours**

Static Force Analysis: Forces, Moments and Torques. Laws of Motion, Free-Body Diagrams, Static Equilibrium, Analysis of a Two-Force Member, Sliding Friction Force, Problems and Case Study.

Dynamic Force Analysis: Mass and Weight, Center of Gravity, Mass Moment of Inertia. Unbalance Effects and Balancing of Inertia Forces in Rotating Bodies of Reciprocating Machines; Field Balancing and Balancing Machines. Turning Moment Diagram for Engines and; Power Smoothening by Flywheels.

Course outcomes:
After studying this course, students will be able to:
1. Know the concepts of mechanisms.
2. Analyze the graphical and analytical methods in mechanism analysis.
3. Calculations of Machines.

Textbook:
1. Rattan S.S, Theory of Machines, Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd Edition 2009.
2. David H. Myszka, Machines and Mechanisms, Fourth Edition, Pearson Education, Inc., 2012

References:
1. J.J. Uicker, G.R. Pennock, J.E. Shigley, Theory of Machines &Mechanisms. Oxford Press 3rd Ed. 2009.
2. Ambekar, Mechanism and Machine theory, PHI, 2007.

Web References:
1.https://nptel.ac.in/courses/105104160/
2. https://nptel.ac.in/downloads/105106116/
3. https://onlinecourses.nptel.ac.in/noc15_ce02

COURSE		CREDITS			MARKS	
NAME	BASIC PROPULSION	L	T	P	CIE	SEE
CODE	20AE5DC BPR	3	0	1	50	50

Course objectives:
1. To understand the working principles of gas turbine and ramjet propulsion systems, the design principles of inlets, combustion chambers, nozzles used in them.
2. To learn the operation of compressors and turbines in gas turbine propulsion systems.
3. To understand the principle and performance of ramjet propulsion.
4. To analyze Engineering concepts of air breathing propulsion systems.

Course pre-requisite: Engineering Thermodynamics

Unit-1 **9 hours**

Thermodynamics of Air breathing Propulsion Systems: Introduction, Thrust and efficiency, The ramjet, Turbojet engines, Turbofan engines, Turboprop and turboshaft engines, Typical engine performance, Engine-aircraft matching (introductory information). Numerical problems.

Unit-2 **9 hours**

Inlets, Combustors, and Nozzles: Introduction, Subsonic inlets, Supersonic inlets, Gas turbine combustors, Afterburners and ramjet combustors, Supersonic combustion, Exhaust nozzle. Numerical problems.

Unit-3 **9 hours**

Axial Compressors: Angular momentum, Work and compression, Characteristic performance of a single compressor stage, Characteristic performance of a multistage axial compressor, Boundary layer limitation, Compressor efficiency, Degree of reaction, Radial equilibrium, Design of a subsonic axial compressor, Transonic fan stage. Numerical problems.

Unit-4 **9 hours**

Axial Turbines: Introduction, The axial turbine stage, Stage efficiency, Rotor blade and disc stresses, Blade cooling, Turbine performance, Turbine and compressor matching, Turbine stage design. Numerical problems.

Unit-5 **9 hours**

Centrifugal Compressor: Introduction, Centrifugal compressor stage dynamics, The inducer and impeller, The diffuser, Performance characteristics, Centrifugal compressor stage design. Numerical problems.

Textbook:
1. Hill, P. G., and Peterson, C. R., Mechanics and Thermodynamics of Propulsion, 2nd Edition, Addison-Wesley Publishing Company, Singapore, 1992.
2. Cohen. H. Rogers. G.F.C. and Saravanamuttoo. H.I.H, Gas turbine theory. 4th edition. Pearson education.

References:
1. Rolls-Roycs, Jet Engine, 3rd edition, 1983.
2. Oats, G.C., Aerothermodynamics of Aircraft Engine Components, AIAA Education Series, New York, 1985.
3. Cohen, H Rogers., G.F.C. and Saravanamutto, H.I.H., Gas Turbine Theory, Longman, 1989.
4. Mattingly, J.D., Heiser, W.H., and Pratt, D.T., Aircraft Engine Design, AIAA Education Series, New York, 2002.

Web References:
1.https://nptel.ac.in/courses/105104160/
2. https://nptel.ac.in/downloads/105106116/
3. https://onlinecourses.nptel.ac.in/noc15_ce02

BASIC PROPULSIONLABORATORY

Course objectives:
This course will enable students to

1. Understand how to do the heat transfer
2. Comprehend the analysis over the surface of the aircraft structure,
3. Study the working of different jet engines, study of propellants etc.

Course pre - requisite: Heat Transfer and Basic Propulsion

1. Study of piston and jet engines.
2. Study of centrifugal compressor and axial compressors.
3. Study of free convective heat transfer over a flat plate.
4. Study of forced convective heat transfer over a flat plate.
5. Determination of heat of combustion of aviation fuel.
6. Study of free jet/wall jet.
7. Performance test on a propeller.
8. Study of hybrid propulsion system.
9. Performance study of hybrid motor using a thrust stand.
10. Testing for performance parameters of a Ramjet engine.

Course outcomes:
After studying this course, students will be able to:

1. Analyze the performance of jet engine.
2. Differentiate among different equipment required for study of propulsion.

COURSE		CREDITS			MARKS	
NAME	ADVANCED AERODYNAMICS	L	T	P	CIE	SEE
CODE	20AE5DC AAD	3	0	1	50	50

Course objectives:
1. To study the principles of compressible flow, that has wide application in aerospace engineering.
2. To have exposure in recent advances made in transonic, supersonic and hypersonic flows.
3. To familiarize with numerical method of characteristics.

Course pre-requisite: Basic Aerodynamics

Unit-1 **12 hours**

Concepts of Compressible Flow: Introduction to isentropic flow-Scope of compressible flow-Review of continuity, momentum and steady flow energy equations and entropy considerations- Energy and momentum equations for compressible fluid flow- reference velocities-stagnation states-velocity of sound-critical states-Mach number-critical Mach number. Types of waves- Mach cones Mach angle-effect of Mach number on compressibility flow regimes.

Unit-2 **12 hours**

Shocks and its Applications: Development of normal shocks-governing equations-Stationery and moving normal shock waves-applications, applications to supersonic wind tunnel. Shock tubes, supersonic pitot probes. Oblique shock- Reflection of flow.

Unit-3 **12 hours**

Expansion Waves and Flow Over Nozzles: Prantl-Meyer expansion flow and related problems. Under and over expanded nozzles, shock expansion method for flow over airfoils.

Unit-4 **12 hours**

Flow in Constant Area Duct With Friction and Heat Transfer: Fanno flow- fanno flow equations and solutions- variation of flow properties variation of Mach number with duct length-tables and charts for fanno flow. Rayleigh line, Rayleigh flow equations-variation of flow properties, tables and charts for Rayleigh flow.

Unit-5 **12 hours**

Brief Introduction to the Methods of Characteristics: Method of characteristics -Prandtl-Glauert and Goethert rules. Ackeret's supersonic airfoil theory. Small perturbation equations for subsonic, transonic, supersonic and hypersonic flow. Experimental characteristics of airfoils in compressible flow.

Textbook:
1. Radhakrishnan, E., "Gas Dynamics", Prentice Hall of India, 1995.
2. Yahya, S. M., "Fundamentals of compressible flow with aircraft and rocket propulsion", Wiley Eastern, 1993.

References:
1. Shapiro, A.H., "The Dynamics and Thermodynamics of Compressible Fluid Flow (Vol I and II)", Ronald Press,1953.
2. Anderson J. D., Jr., "Modern Compressible Flow with Historical Perspective," McGraw Hill Publishing Co., 1990.
3. Miles, E.R.C., "Supersonic Aerodynamics", Dover, New York, 1950.

Web References:
1.https://nptel.ac.in/courses/105104160/
2. https://nptel.ac.in/downloads/105106116/
3. https://onlinecourses.nptel.ac.in/noc15_ce02

ADVANCED AERODYNAMICS LABORATORY

Course objectives:
At the end of the course students will be able
1. To analyze pressure distribution in 3-D objects
2. To calibrate a supersonic wind tunnel
Course pre - requisite: Advanced Aerodynamics

Unit-A ESTIMATION AERODYNAMICS 15 hours

1. Calibration of supersonic wind tunnel
2. Estimation of forces acting over a symmetrical airfoil with different angle of attack
2. Estimation of forces acting over an unsymmetrical airfoil with different angle of attack
3. Study of forces acting on the finite wing with washin angle of 10^0
4. Study of forces acting on the finite wing with washout angle of 10^0
5. Study of forces acting on the finite wing with movable flap.

Unit-A VISUALIZATION AERODYNAMICS 15 hours

1. Study of supersonic flow over a diamond shape airfoil with half wedge angle of 8^0 by flow visualization.
2. Study of supersonic flow over a diamond shape airfoil with half wedge angle of 35^0 by flow visualization.
3. Study of supersonic flow over a cone by flow visualization.
4. Study of supersonic flow over a cylinder by flow visualization.

Course outcomes:
After studying this course, students will be able to understand the fluid flow, pressure distribution and forces on airfoil and finite wing models.

References:
1. Laboratory manual

COURSE		CREDITS			MARKS	
NAME	INTRODUCTION TO CONTROL THEORY	L	T	P	CIE	SEE
CODE	20AE5DC ICT	3	0	0	50	50

Course objectives:

1. Teach students the principles of classical control theory.
2. Introduce students to transfer function forms, state space models and observers.
3. Analyze the stability of systems using various time domain and frequency domain tools.
4. Demonstrate examples in aerospace systems, especially towards aircrafts and spacecraft.

Course pre-requisite: Engineering Mathematics

Unit-1 **9 hours**

Introduction: Historical review, Concept of automatic controls, Application of controls in aerospace engineering - Structural mechanics, Propulsion, Flight mechanics, space flight, vibration suppression, smart materials. Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system. Design consideration of control systems.

Mathematical Models: Transfer Function and Impulse-response function, Automatic control systems, Modeling in state-space, State-Space representation of scalar differential equation systems, Types of controllers- Proportional, Integral Differential and combination controllers. Modeling of linear and non-linear systems.

Unit-2 **9 hours**

Mathematical Modeling of Mechanical, Fluid, Thermal and Electrical Systems: Mathematical modeling of mechanical systems, Mathematical modeling of fluid systems - Liquid level, pneumatic and hydraulic systems, Mathematical modeling of electrical systems, Analogous systems - Force voltage, Force current

Block Diagrams and Signal Flow Graphs: Transfer Functions definition, function, Block diagram representation of control systems, reduction of block diagrams, Output to input ratios. Signal flow graphs: Mason's gain formula.

Unit-3 **9 hours**

Transient and Steady State Response Analysis: Introduction, Laplace transformation, first order and second order system response to step, ramp and impulse pulse, parabolic and sinusoidal inputs, concepts of time constant and its importance in speed of response. Time response of first and second order systems, steady state errors and error constants of unity feedback circuit.

Unit-4 **9 hours**

Root Locus Plots: Definition of root loci, General rules for constructing root loci, Analysis using root locus plots. Frequency Response Analysis: Polar plots, Nyquist stability criterion, Stability analysis, Gain margin and phase margin.

Unit-5 **9 hours**

System Compensation and State Variable Characteristics of Linear Systems: Series and feedback compensation, Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and Observability, Kalman and Gilberts test. Controllability and observability of linear time invariant systems, Linear quadratic observer.

Course outcomes: After studying this course, students will be able to:
1. Understand and apply the principles of feedback control systems.
2. Understand and use state-space models, observers, and controllers.
3. Understand the basic design of control systems for aerospace applications.

Textbook:
1. Katsuhiko Ogatta, Modern Control Engineering, Pear son Education,5th Edition,2015.
2. M.Gopal, Control Systems Principles and Design,TMH,4th edition,2012,ISBN-13: 9780071333269.

References:
1. Richard.C.Dorf and Robert.H.Bishop, Modern Control Systems, Pearson Education India,12th edition,2013,ISBN-13: 978-9332518629
2. Eronini-Umez, System dynamics &control, Thomson Asia Pvt Ltd. Singapore,
3. Schaum's 2002. series, Feedback Control System, 2001:
4. N. S. Nise: Control Systems Engineering, 4th Ed., Wiley, 2004.
5. B. Friedland: Control System Design, Mc.Graw Hill, 1986.
7. M. Gopal: Modern Control System Theory, 2nd Ed., Wiley, 1993.
8. H. J. Marquez: Nonlinear Control Systems Analysis and Design, Wiley, 2003.
9. J-J E. Slotine and W. Li: Applied Nonlinear Control, Prentice Hall, 1991.
10. H. K. Khalil: Nonlinear Systems, Prentice Hall, 1996.
11. A. Isidori: Nonlinear Control Systems, 3rd Ed., Springer, 1995.
12. A. E. Bryson and Y-C Ho: Applied Optimal Control, Taylor and Francis, 1975.
13. J. L. Crassidis and J. L. Junkins: Optimal Estimation of Dynamic Systems, CRC Press, 2004.
14. W. S. Levine (Ed): The Control Handbook, CRC and IEEE Press, 1996.
15. R. C. Nelson: Flight Stability and Automatic Control, McGraw Hill, 1989.

Web References:
1. https://nptel.ac.in/courses/101/108/101108047/
2. https://www.youtube.com/watch?v=okdV48SLbNg
3. https://www.youtube.com/playlist?list=PLUMWjy5jgHK3j74Z5Tq6Tso1fSfVWZC8L

COURSE		CREDITS			MARKS	
NAME	BASIC FLIGHT MECHANICS	L	T	P	CIE	SEE
CODE	20AE5DC BFM	3	0	1	50	50

Course Objective:

1. Apply equations of motion for an aircraft. Assess performance of aircrafts for climb, steady flight and turn.
2. Glide, take-off and landing performance evaluation. Evaluate the climb, steady flight and turn performance of piston-engine aircrafts.
3. To instruct the basic concepts of Aircraft stability and control
4. To train the students on longitudinal, lateral, directional stability and control and its effect on airframe components.

Course Pre-requisites:

Basic understanding of flight, Aerodynamics.

Unit-1

Equations of Motion – Forces Acting on the Aircraft, Review of Propulsion Systems and their Performance Characteristics, Drag Contribution from Aircraft Components, Airplane Performance of Turbojets - Steady Flight, Range, Endurance, Conditions for Maximum Range and Endurance, Climb Performance, Turn Performance, Maximum Load Factor during Turn.

Unit-2

Glide Performance - Take-Off and Landing, Performance of Piston-Props - Steady Flight Climb, Turn Performance, Climb Performance, Comparison with Turbojets - Turbofan and Turboprop Performance Evaluation Guidelines.

Unit-3

Static Longitudinal Stability Stick fixed: Definition of static stability, Stability criteria, Contribution of airframe components: Wing contribution, Tail Contribution and Fuselage contribution. Power effects. Static Margin.

Static Longitudinal Control: Introduction, Trim condition, Stick fixed neutral points, Elevator Power Estimation, Elevator angle versus equilibrium lift coefficient, Restriction on forward C.G. range.

Unit-4

Static Longitudinal Stability Stick free: Introduction, Hinge moment coefficient, stick force gradient, Trim tabs, Stick free neutral point, Restriction on aft C.G.

Static Directional Stability and Control: Definition of directional stability, Weather cocking effect, Contribution of airframe components, Directional Control, Dorsal Fin, One Engine inoperative condition, Rudder Lock.

Unit-5

Static Lateral Stability and Control: Introduction, Definition of Roll stability, Dihedral effect, Lateral control, Effect of wing sweep, flaps and power-on dihedral effect, Adverse yaw effects, Aileron Reversal, Balancing the aileron.

Text Books

1. Aircraft Performance and Design, John D Anderson, Jr. McGraw-Hill International Editions, Aerospace Science/ Technology, 1999
2. Flight Stability and Automatic Control, Nelson, R.C, McGraw-Hill Book Co, 2007
3. Airplane Performance stability and Control, Perkins C D and Hage R E, John Wiley Son Inc, New York, 1988

Course outcomes: After completion of the course students will be able to

CO1: Understand and apply equations of motion for an aircraft. Evaluate performance of turbojet aircrafts for climb, steady flight and turn.

CO2: Glide and take-off and landing performance evaluation. Evaluate the climb, steady flight and turn performance of piston-engine aircrafts

CO3: Capable to evaluate longitudinal, directional and lateral static stability and control. Understand the principle of

dynamic stability.
CO4: Apply the understanding for the preliminary design of control surfaces.

COURSE		CREDITS			MARKS	
NAME	HELICOPTER DYNAMICS	L	T	P	CIE	SEE
CODE	20AE5DE HLD	3	0	0	50	50

Course objectives:

CO1: Comprehend basics of helicopter

CO2: Understand helicopter flight mechanics and performance

CO3: Understand development of helicopter dynamic system

Course pre requisite: Basic aerodynamics, flight mechanics, vibration

Unit 1 9 hours

Introduction: History of helicopter flight, gyrocopter,basic configuration of the helicopter, helicopter components, rotors, flight characteristics , comparison with fixed wing aircraft, helicopter applications.

Helicopter flight: fundamentals of flight, functions of main and tail rotors, rotor disc,hover and forward flight. Helicopter configurations. Major components of the helicopter.

Rotor blade, flap, lead lag and torsion hinges, articulated rotor, hinge offset, rotor head, dynamic system of the helicopter, rotor speed, centrifugal force on the blade

Momentum theory: for hovering rotor, induced velocity, disc loading, figure of merit, thrust and power coefficients.

Blade element theory: in hover, solidity, pre twist of blade, ideal and actual lift distribution on blade, tip loss factor. Blade element theory in vertical flight.

Unit 2 9 hours

Equilibrium of blade about flap and lead-lag hinges, blade coning angle and lag angle.

Basic Helicopter Performance: Forces acting on helicopters in forward flight. Methods of achieving forward and lateral flights. Power required for flight, effects of gross weight and density altitude.

Advancing and retreating blade, advance ratio, azimuth angle, compressibility and stall effects.

Helicopter speed for minimum power and speed for maximum range.

Rotor control: collective and cyclic pitch inputs to rotor, swash plate mechanism. Blade motion about hinges.

Unit 3 8 hours

Airfoil aerodynamics: Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics. Blade tip shapes

Rotor Wake and Blade Tip Vortices: Characteristics of rotor wake in hover, vertical flight, descent and forward flight. Ground effect on hovering rotor. Auto rotation.

Unit 4

9 hours

Helicopter Stability and Control: Introductory concepts of stability. Forward speed disturbance, vertical speed disturbance, disturbances in pitch and yaw. Static and dynamic stability of helicopters.

Helicopter vibration, blade lead lag damper, blade static balancing, ground resonance, effects of vibration

Ground and flight tests: Strength and stiffness tests, functional tests on whirl tower. Flight testing of helicopter.

Unit 5 10 hours

Standards and specifications: Civil and military design requirements. Structural design, strength and stiffness.

Conceptual design: Parameters such as Rotor diameter, number of blades, airfoil selection, twist, Lock number.

Conventional tail rotor and ducted fan tail rotor, tail rotor control.

Fuselage and empennage, landing skid and landing gear, damage tolerance

Tail drive shaft, free wheel, helicopter engines.

State of the art: Hinge less and bearing less rotors. Tilt rotor aircraft. High speed rotor craft. UAV rotorcraft

Course outcome:

CO1: Apply concepts of rotor craft

CO2: Computation of induced velocity, coning angle, lag angle, longitudinal force on blade

CO3: Innovative applications of UAV rotorcraft

Text books:

1. Aerodynamics of the helicopter A. Gessow and G. C. Myers, College Park press, Maryland
2. Helicopter aerodynamics R. W. Prouty, Eagle Eye Solutions

References:

3. The foundation of helicopter flight Simon Newman, Elsevier
4. Basics helicopter aerodynamics J. Seddon and S. Newman, Wiley
5. Helicopter theory Wayne Johnson, Dover Publications

COURSE		CREDITS			MARKS	
NAME	ADVANCED THERODYNAMICS	L	T	P	CIE	SEE
CODE	20AE5DE ADT	3	0	0	50	50

Course Content:

UNIT - I

Unsteady flows and exergy analysis: First law of thermodynamics applied for unsteady flows with energy transaction, Available energy, Exergy, Availability analysis of open and closed systems, Maxwell Relations, Joules Thompson coefficient, Phase diagram, Clapeyron's equation.

06 Hours

UNIT-II

Refrigerants and Psychrometry: Thermodynamic properties, Refrigerant mixtures: Azeotropic and Zeotropic, Procedure to construct Psychrometric chart and First law applied to Psychometry, Enthalpy and entropy calculations .

06 Hours

UNIT – III

Chemical Thermodynamics and Combustion: Reaction Equilibrium, Law of Mass of Action, Heat of Reaction, Temperature Dependence of the Heat of Reaction, Temperature Dependence of the Equilibrium Constant, Gibbs Function Change, Fugacity and Activity, Displacement of Equilibrium due to a change in Temperature or Pressure, Heat Capacity of Reacting Gases in Equilibrium, Enthalpy of Formation, First Law for Reactive Systems, Adiabatic Flame Temperature

10 Hours

UNIT – IV

Kinetic theory of gases: Introduction, Molecular collisions with a stationary wall, Absolute temperature of a gas, Derivation from ideal gas behaviour, Maxwell-Boltzmann velocity distribution and its applications, Evaluation of elementary properties of a gas based on kinetic theory, Principle of equipartition of energy.

Transport phenomena-intermolecular forces, The Van der Waals equation of state, collision cross section, mean free path.

10 Hours

UNIT - V

IRREVERSIBLE THERMODYNAMICS: Conjugate Fluxes and Forces, Linearized Relations, Reciprocity Relations, Thermoelectric Phenomena, Formulations, Peltier Effect, Seebeck Effect, The Thomson Effect, Power Generation, Refrigeration.

07 hours

Textbooks:

1. Fundamental Thermodynamics, Claus Borgnakke and Richard E. Sonntag, Wiley Publication.
2. Refrigeration and Air conditioning - CP Arora, McGraw-Hill Companies.
3. Advanced Engineering Thermodynamics, Andrian Bejan, 4th edition, Wiley, , McGaw Hill, 2016.
4. Thermodynamics, Kinetic Theory and Statistical Thermodynamics, F.W.Sears and G. L. Salinger, Narosa Publishing House, New Delhi, 3rd edition, 1998.

References Books:

1. Engineering Thermodynamics - P.K. Nag, Tata McGraw-Hill Publications
2. M.J.Moran and H.N.Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons, 2008.
3. I. K. Puri and K. Annamalai, Advanced Engineering Thermodynamics, CRC Press, 2001.

E Books/Web references

1. https://nptel.ac.in/courses/112103016/

MOOCS

1. https://www.mooc-list.com › tags › thermodynamics
2. https://bookboon.com › engineering-thermodynamics-ebook

Course Outcomes:

Upon completion of this course, the student will be able to,

CO1	Apply the concepts of basic thermodynamic for analyses of thermal energy systems
CO2	Construct Psychrometric chart and to develop the thermodynamic properties of refrigerants
CO3	Understand the concepts of combustion phenomena and chemical reaction in energy conversion devices.
CO4	Understand the kinetic theory perspective of for gases and obtain Maxwell-Boltzmann distributions and Van der Waals equation. Evaluating them with examples.
CO5	Analyse the Peltier, Thomson and Seeebck effects. Understanding their applications in power generation and refrigeration systems.

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set one question each from unit I, II, V and Two questions each from units III& IV.

COURSE		CREDITS			MARKS	
NAME	ENTREPRENEURSHIP	L	T	P	CIE	SEE
CODE	20HS5IC EPP	2	0	0	50	50

Course objectives:

1. To impart skills in entrepreneurship.
2. To train the students to read and understand the setting of small scale industry.

Course pre-requisite: Nil

Unit-1 10 hours

Management: Introduction, Meaning, Nature and functions of management, Roles of Manager, Managerial Skills, Management as a science, art or profession- Management & Administration, Development of Management thought- early management (Taylor & Henri Fayol) approaches and Modern Management (Qualitative, Contingency & Systems) approaches

Planning: Nature & importance of planning, Forms of planning, Types of plans, Importance of Planning, Steps in planning process, Planning premises, Limitations of planning Decision making, Types of decisions, Steps in decision making, Difficulties in decision making.

Unit-2 06 hours

Organizing: Meaning, Characteristics and Process of organizing, Span of Management, Principles of Organizing, Organization structure, Types of Organizations

Staffing: Introduction, Functions of staffing, Importance, Short term, long term manpower planning, Recruitment, Selection, Placement, Induction, Training and Mentoring

Unit-3 06 hours

Directing & Controlling: Introduction, Requirements of effective direction, Motivation (Maslow, Hezberg, McGregor theory) Leadership styles (Autocratic, Democratic & Free rein)

Communication: Importance of Communication, Purposes of communication, Formal & Informal communication, Barriers to communication.

Co-ordination and Control: Techniques of co-ordination, Meaning and steps in control process, Essentials of effective control system.

Unit-4 06 hours

Entrepreneurship: Introduction, Characteristics of a successful entrepreneur, Classification of entrepreneurs, Stages of Entrepreneurship, Role of entrepreneur in economic development, Problems faced by entrepreneurs.

Unit-5 10 hours

Small Scale Industry: Definitions of SSI, Importance of SSI, Definitions of SSI, Problems faced by SSI, Prospects of SSI in a free economy. Institutions supporting SSIs central and state wise, Industry Associations, Different Schemes, TECKSOK, KIADB; KSSIDC; KSIMC; DIC Single Window Agency; SISI, NSIC, SIDBI, KSFC.

Setting-up a Small Business Enterprise: business opportunities, formalities for setting up of a small business enterprise, Preparation of Business Plan, Sickness in SSI

Course outcomes:

At the end of the course the student will be able to:

1. CO1: Apply the basic concepts of helicopter dynamics.
2. CO2: Compute the critical speed by using various methods.
3. CO3: Distinguish the turbo rotor system stability by using transfer matrix and finite element formulation.

Textbook:

1. Essentials of Management – Harold Koontz, Heinz Weihrich, Fifth Edition, Tata McGraw Hill
2. Principles of Management – P.C. Tripathi, P.N. Reddy, Tata McGraw Hill,
3. Entrepreneurship Development – Small Business Enterprises – Poornima M. Charantimath – Pearson Education – 2006.

References:

1. Management Fundamentals – Concepts, Application, Skill Development – Robert Lusier – Thomson
2. Essentials of Entrepreneurship and Small Business Management-Thomas W Zimmerer and Norman M Scarborough, Doug Wilson, Fifth Edition, PHI, New Delhi.
3. Management – Stephen Robbins – Pearson Education / PHI – 17th Edition, 2003.

Web References:

1. https://india.gov.in/topics/industries/micro-small-medium-enterprises
2. http://www.archive.india.gov.in/business/starting_business/index.php
3. https://www.class-central.com/subject/management-and-leadership
4. https://www.class-central.com/subject/entrepreneurship

Syllabus for VI Semester

COURSE		CREDITS			MARKS	
NAME	AEROSPACE STRUCTURES	L	T	P	CIE	SEE
CODE	20AE6DC AST	3	0	1	50	50

Course Objective:

1. To impart knowledge on basics of aircraft structural design
2. To instruct the bending in symmetrical and unsymmetrical sections
3. To train on shear flow in open and closed sections
4. Compute the buckling of plates, joints and fittings.

Course Pre-requisites:

Basic course on Strength of Materials

Unit-1

Introduction: Introduction to different aerospace structures, loads on an aircraft, characteristics of aircraft structures, basic structural members in aircraft structures and their functions.

Theory of Bending: Stresses in beams of symmetrical and unsymmetrical sections, General formula for bending stresses, Principal axes method, Neutral axis method.

Unit-2

Shear Flow in Open Sections: Shear stresses in thin walled beams, Concept of shear flow, Shear center, Elastic axis, Shear flow in a section with one axis of symmetry, with wall effective and ineffective in bending.

Unit-3

Shear Flow in Closed Sections: Bredt - Batho formula, Single & multi – cell structures, shear flow in single & multi - cell structures under torsion. Shear flow in single and multi – cell under bending with walls effective and ineffective.

Unit-4

Buckling of Plates: Rectangular sheets under compression, Local buckling stress of thin walled sections, Crippling stresses by Needham's and Gerard's methods, thin walled column strength. Sheet stiffener panels, effective width, inter rivet and sheet wrinkling failures.

Unit-5

Stress Analysis in Wing and Fuselage: Shear and bending moment distribution for semi cantilever and other types of wings and fuselage. With parallel and non-parallel flanges, Shear resistant web beams, Tension field web beams (Wagner's).

Text Books

1. Aircraft Structures for Engineering Students, T.M.G Megson, Edward Arnold, 1995.
2. Analysis and Design of Flight Vehicle Structures, Bruhn E.H, Tristate off set company, USA, 1985
3. Aircraft Structures, Peery D.J & Azar J.J, McGraw-Hill, New York, 2nd Edition, 1993

Reference Books

1. Mechanics of Aircraft Structures, C.T Sun, John Wiley & sons, New York, 2006
2. Theory and analysis of flight structures, Rivello, R.M, McGraw-Hill, New York, 1969
3. Fundamentals of Astrodynamics and Applications, David A. Vellado, Springer, Germany, 3rdEdition,2007

Online Web References

1. https://nptel.ac.in/courses/101/105/101105022/
2. https://swayam.gov.in/nd1_noc20_ae08/preview
3. https://ocw.tudelft.nl/courses/introduction-aerospace-structures-materials/?view=lectures&subject=32891

Course outcomes: After completion of the course students will be able to

CO1: Understand the aircraft structures.
CO2: Analysis of non-circular torsional members
CO3: Evaluate the bending stresses and flexural shear flows in thin walled sections
CO4: Investigate the torsional shear flows in thin walled sections
CO5: Illustrating the concepts of buckling for thin walled sections.

B.M.S.COLLEGE OF ENGINEERING, BENGALURU

Autonomous College under VTU

DEPARTMENT OF AEROSPACE ENGINEERING

COURSE		CREDITS			MARKS	
NAME	COMBUSTION	L	T	P	CIE	SEE
CODE	20AE6DC COM	3	0	1	50	50

Prerequisites: Aero-Thermodynamics, Aero-Heat and Mass transfer, Aero-Fluid Mechanics

Course Outcomes

- To provide students with fundamental concepts of combustion
- Understand fundamental theory of the combustion of non-premixed and premixed flames
- To make combustion calculation
- Understand pollutant formation in combustion devices

Unit1

Combustion Introduction and Thermochemistry

Introduction to Combustion, fuel & oxidizer, Review of property relations, Extensive and Intensive property, Equation of state, Ideal gas mixtures, Latent heat of evaporation, first law of thermodynamics, First law fixed mass, control volume, Reactant and product mixtures, stoichiometry, Equivalence ratio, Enthalpy of formation, Enthalpy of combustion and heating values, Equilibrium constants, Determination of Adiabatic flame temperature, Chemical equilibrium, second law consideration, Gibbs function. **[9]**

Unit 2

Chemical kinetics and Transport process

Fundamentals of elementary reaction, law of mass action, first, second and third order reaction, Chain Branching, Simple reaction mechanism, Quasi Steady State Approximation, Partial Equilibrium Approximation method. Laws of transport phenomena, transport properties of gas mixtures, Conservation of Mass, Momentum, Energy Equation and Species governing equation. **[9]**

Unit 3

Laminar premixed flames

1D combustion wave, laminar flame theory, flame thickness, burning velocity measurements, structure of premixed flames, dependence of flame speed on equivalence ratio, temperature and pressure, flammability limits, flame quenching, Ignition, flame stabilization. **[9]**

Unit 4

Laminar Diffusion flames

Candle flame, structure of non-premixed laminar free jet flames, laminar jet flame height, Burke- Schumann Jet diffusion flame, Flame lift off and blow off. Droplet vaporization in quiescent air, droplet vaporization in convective flow, Droplet combustion. Burning of solids **[9]**

Unit 5

Combustion technology & Pollutant Emissions

Solid, liquid & gaseous fuel - combustion devices, factors affecting combustion efficiency – fuels used for gas turbine combustion, Alternate fuels, Emission from combustion systems, Health hazards, Negative effects of combustion products, pollution formation, parameters controlling formation of pollutants, CO oxidation, Mechanism of NO formation, controlling NO formation. 54 **[9]**

Books:

1. Turns, S.R., An Introduction to Combustion, McGraw-Hill, 2000.
2. Understanding Combustion by H.S Mukunda, University press, 2nd edition.
3. Strehlow, R.A., Combustion Fundamentals, McGraw-Hill, 1985.
4. Kuo, K.K., Principles of Combustion, Wiley, 1986.
5. Law, C.K., Combustion Physics, Cambridge University Press, 2006.
6. Williams, F.A., Combustion Theory, 1985.

Web references

https://nptel.ac.in/courses/101/104/101104014

https://nptel.ac.in/courses/101/104/101104072/

COURSE		CREDITS			MARKS	
NAME	ENGINEERING DESIGN AND OPTIMIZATION	L	T	P	CIE	SEE
CODE	20AE6DC EDO	3	0	0	50	50

Course objectives:

1. To prepare students with adequate knowledge in design and optimization in aerospace engineering.

Course pre- requisite: Solid Mechanics, Fluid Mechanics, Propulsion and Basic Concepts of Calculus.

Unit-1 **8 hours**

Introduction to Design Process: Design Process - Considerations of Good Design, Product and Process Cycle, Technological Forecasting, Market Identification, Customer Needs, Competition Bench Marking. Product Architecture, Design Specifications, Conceptual Design - Creativity and Problem Solving, Evaluation Methods, Embodiment Design. Quality and Cost, Mathematical and Geometric Modeling, Computer Aided Engineering, Simulation and Testing, Concurrent Engineering.

Unit-2 **8 hours**

Design of Aerospace Systems: Preliminary Design Consideration for Aerospace Systems – Structural, Aerodynamic, Hydraulic, Thermal, Performance and Ergonomic Parameters. Selection of Standards, Materials and Elements. Aerospace Vehicle Design Case Studies: Design Methodology of Aircrafts and UAVs - Literature, Systems, Components and Selections.

Unit-3 **8 hours**

Introduction to Optimum Design: Engineering Applications of Optimization - Statement of an Optimization Problem. Classification of Optimization Problems, Optimum Design Concepts, Optimization Techniques - Classical and Advanced Techniques - Mathematical Models and Graphical Optimization, Unconstrained and Constrained. Review of Programming forOptimization. Engineering Optimization Literature - Solution of Optimization Problems using MATLAB.

Unit-4 **8 hours**

Methods for Optimum Design: Linear Programming - Introduction, Standard LP Problem, Simplex Method, Artificial Variables, Post-optimality Analysis, Duality in Linear Programming. Quadratic programming – Golden Search, Steepest Decent, Gradient and Newton's Method. Engineering Applications.

Unit-5 **8 hours**

Optimum Design for Aerospace Engineering: Formulation and Issues in Practical Design Optimization, Multi-objective and Multidisciplinary Design Optimization. Gradient Evaluation, Practical Design Optimization Procedure - Convexity, Kuhn
–Tucker Conditions, Sufficiency Check, Sensitivity Analysis. Optimum Aerospace Design Case Studies: System and Component Problems.

Course outcomes:

After studying this course, students will be able to:

1. Know the concepts of engineering system.
2. Know the concepts of engineering optimization.
3. Design and optimize the aerospace engineering problems.

Textbook:

1. Dieter, George E., Engineering Design - A Materials and Processing Approach, McGraw Hill, InternationalEditions, Singapore, 2000.
2. Rao, Singaresu, S., Engineering Optimization – Theory & Practice, New Age International (P) Limited, New Delhi, 2000.
3. Jasbir S. Arora, Introduction to Optimum Design, McGraw Hill Edition 1989.
4. Corke, T. C., Design of Aircraft, Prentice Hall 2002.

References:

1. Pahl, G, and Beitz, W., Engineering Design, Springer - Verlag, NY. 1984.
2. Suh, N.P., The Principles of Design, Oxford University Press, NY.1990.
3. Karl T. Ulrich and Steven D. Eppinger, Product Design and Development, McGraw Hill Edition, 2000.
4. Torenbeek, Egbert. Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes.John Wiley & Sons, 2013.
5. Reg Austin, Unmanned Aircraft Systems, John Wiley & Sons Ltd, 2010
6. Johnson Ray, C., Optimum Design of Mechanical Elements, Wiley, John & Sons, 1990.
7. Kalyanamoy Deb, Optimization for Engineering Design Algorithms and Examples, Prentice Hall of India Pvt, 1995.
8. Goldberg, D.E., Genetic Algorithms in Search, Optimization and Machine, Barnen, Addison Wesley, New York, 1989.

Web References:

1. https://nptel.ac.in/courses/107/108/107108010/
2. https://nptel.ac.in/courses/112/107/112107282/
3. https://engineering.purdue.edu/online/courses/optimization-aerospace-engineering3.
https://nptel.ac.in/courses/105/108/105108127/

COURSE		CREDITS			MARKS	
NAME	FLIGHT DYNAMICS AND SPACE	L	T	P	CIE	SEE
CODE	20AE6DC DSM	3	0	1	50	50

Course Objective:

1. To train the students on longitudinal dynamic stability and control of aircraft.
2. To train the students on lateral, directional dynamic stability and control of aircraft
3. Understand and develop basic concepts in Space Mechanics and Two Body Problem

Course pre- requisite: Basic of Aerodynamics, Basic flight Mechanics

Unit-1

Review of Concepts to Static Stability, Review of Introduction to Dynamic Stability, Body Axis, Stability Axis, Earth Axis, Euler Angles, Transformation between axis, Advantages of different axis, Aircraft Equations of Motion.

Unit-2

Small Perturbation Theory: Linear Equations of Motion, Stability Derivatives - Derivatives due to change in forward speed, Derivatives due to the pitching velocity, Derivatives due to the time rate of change of angle of attack, Derivatives due to rolling rate, Derivatives due to yawing rate.

Unit-3

Dynamic Stability: Definition of Dynamic longitudinal stability: types of modes of motion: long or phugoid motion, short period motion. Dynamic stability in lateral and directional motions - Dutch roll and Spiral instability, Autorotation and Spin.

Unit-4

Space Environment: Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite life time.

Unit-5

Basic Concepts and the General N-Body: The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts, Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, the many body problem, Lagrange-Jacobi identity, the circular restricted three body problem, the general N-body problem, two body problem, relations between position and time.

Text Books

1. Flight Stability and Automatic Control, Nelson, R.C, McGraw-Hill Book Co, 2007
2. Airplane Performance stability and Control, Perkins C D and Hage R E, John Wiley Son Inc, New York, 1988
3. Rocket Propulsion and Space flight Dynamics, J. W. Cornelisse, Pitman Publishing, London, 1979
4. Fundamentals of Astrodynamics, Roger R Bate, Donald D Mueller, Jerry E White and William W Saylor, 2nd edition, Dover, 2015
5. Introduction to Space Dynamics, Thomson, Dover Publications, Revised edition, 2012

Reference Books

1. Space flight Dynamics, William E. Wiesel, McGraw-Hill,3rd Edition, New Delhi,2010
2. Modern Spacecraft Dynamics and Control, Kaplan, Marshall H., John Wiley & Sons, New York, 1976
3. Fundamentals of Astrodynamics and Applications, David A. Vellado, Springer, Germany, 3rdEdition,2007

Online Web References

1. https://nptel.ac.in/courses/101/104/101104062/
2. https://nptel.ac.in/courses/101/105/101105083/
3. https://nptel.ac.in/courses/101105030/

COURSE		CREDITS			MARKS	
NAME	VIBRATION THEORY AND AERO-ELASTICITY	L	T	P	CIE	SEE
CODE	20AE6DC VTA	3	0	0	50	50

PRE-REQUISITES:
1. Engineering Mechanics
2. Engineering Physics
3. Engineering Mathematics

OBJECTIVES:
Course Learning Objectives:
- Understand the basic concepts of vibrations.
- Understand the working principle of vibration measuring instruments.
- Understand the aero-elastic effects of aircraft wing.

UNIT -1
Introduction: Types of vibrations, S.H.M, principle of super position applied to Simple Harmonic Motions. Beats, Fourier theorem and simple problems. **07 Hours**

UNIT -2
Undamped Free Vibrations: Single degree of freedom systems. Undamped free vibration, natural frequency of free vibration, spring and Mass elements, effect of mass of spring, Compound Pendulum.
08 Hours

UNIT -3
Damped Free Vibrations: Single degree of freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement. **08 Hours**

UNIT -4
Forced Vibration: Single degree of freedom systems, steady state solution with viscous damping due to harmonic force. Solution by complex algebra, vibration isolation, transmissibility ratio due to harmonic excitation and support motion.
Vibration Measuring Instruments: Vibration measurement scheme, vibrometer and accelerometer, Frequency measuring instruments. **09 Hours**

UNIT-5
Elements of Aeroelasticity:
Vibration due to coupling of bending and torsion – aeroelastic problems - collars triangle - wing divergence - aileron control reversal – flutter – buffeting. – Elements of servo elasticity.
Numerical Methods for Multi Degree Freedom Sysytem:
Approximate methods – Rayleigh's method – Dunkerlay‟s method – Rayleigh-Ritz method and matrix iteration method. **08 Hours**

TEXT BOOKS:

1. Mechanical Vibrations (English) 8th Edition, G. K. Grover, Nem Chand and Brothers.
2. Mechanical Vibrations: V.P. Singh, Dhanpat Rai & Company Pvt. Ltd., 3rd edition, 2006.
3. Mechanical Vibrations and Noise Engineering, A.G. Ambekar, 2nd Edition, 2006.
4. Aero elasticity, Bisplinghoff R.L., Ashely H and Hogman R.L.," – Addision Wesley Publication, New York, 1983.

REFERENCE BOOKS:

1. Mechanical Vibrations: S.S. Rao, Pearson Education Inc., 4th Edition, 2003.
2. Mechanical Vibrations: S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill, Special Indian edition, 2007.
3. Theory & Practice of Mechanical vibrations: J.S. Rao & K. Gupta, New Age International Publications, New Delhi, 2001.
4. Theory of Vibration with Applications: W.T. Thomson and Marie Dillon Dahleh, Pearson Education 5th edition, 2007.
5. Elements of Vibrations Analysis: Leonanrd Meirovitch, Tata McGraw Hill, Special Indian edition, 2007.

MOOCs:

1. Mechanical Vibrations - http://nptel.ac.in/courses/112103112/
2. Mechanical vibrations – http://ocw.mit.edu/courses/mechanical-engineering

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Understand the vibration and its types also apply the basics of mathematics to determine the harmonic series by Fourier theorem.
CO2	Apply the basics of engineering such as Newton's second law and the principle of conservation of energy to model mechanical systems using mass, spring(Without damper) elements and develop mathematical models to obtain their governing equations of motion and hence their response
CO3	Develop the mathematical models to obtain their governing equations of motion by applying the basics of engineering such as Newton's second law and the principle of conservation of energy to model mechanical systems using mass, spring and damper elements s
CO4	Ability to analyze the vibrational motion of 1-DOF mechanical systems under harmonic excitation conditions. And determine the vibrations using vibration instruments.
CO5	Apply the Knowledge acquired in aero elasticity and fluttering. Compute the responses of multi degree of freedom systems through approximation methods and interpret the results.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit. To set one question each from Unit 1, 2, & 3 and two questions each from Units 4 & 5.

COURSE		CREDITS			MARKS	
NAME	TURBULENCE IN FLUID FLOWS	L	T	P	CIE	SEE
CODE	20AE6DE TFF	3	0	0	50	50

Course Objective:

1. To train, the students teach the fundamentals of turbulent flows.
2. To impart knowledge to students on a statistical representation of turbulent flows, energy cascade, Kolmogorov hypothesis, wall-bounded flows.
3. To introduce turbulence modelling.

Pre-requistes: Basic Fluid Dynamics, Boundary Layers

UNIT-1

Introduction : Nature of turbulent flows, irregularity, diffusivity, three-dimensional motions, dissipation, wide spectrum, the origin of turbulence, eddy motions and length scales, Introduction to Tensors.

UNIT-2

Statistical Description of Turbulence: Random nature of turbulence, distribution function, probability density function, moments, correlations, Taylor's hypothesis, Integral micro scales, homogeneous and isotropic turbulence, Kolmogorov hypothesis, scales of turbulence, energy cascade, turbulence spectra.

UNIT-3

Turbulent Transport of Momentum and Heat: Reynolds decomposition, turbulent stresses, vortex stretching, Reynolds Averaged Navier Stokes (RANS) equation, mixing-length model, Reynolds' analogy, dynamics of turbulence.

UNIT-4

Wall Bounded Turbulent Flows: Channel and pipe flow, Reynolds stresses, turbulent boundary layer equations, logarithmic-law of walls, turbulent structures.

UNIT-5

Turbulence Modelling: Introduction, eddy-viscosity hypothesis, Desirable futures of a model of turbulence; Zero, one, half, two and three equation models of turbulence, Reynolds stress model, Algebric Stress model, near-wall treatment, Liminations of RANS approach, Introduction to LES and DNS.

TEXTBOOKS

1. Tennekes, Hendrik, and John L. Lumley, "A first course in turbulence", MIT press, 2018.
2. Stephen B. Pope, "Turbulent Flows", Cambridge University Press.

References

1. Davidson, Peter Alan,"Turbulence: an introduction for scientists and engineers." Oxford university press, 2015.
2. G.Biswas and V.Easwaran,"Turbulent Flows: Fundamentals, Experiments and Modelling", CRC press.
3. Frisch, Uriel, and Andreĭ Nikolaevich Kolmogorov, "Turbulence: the legacy of AN Kolmogorov." Cambridge university press, 1995.
4. Bradshaw, Peter. " 'Review of' Turbulence-An Introduction for Scientists and Engineers". AIAA Journal 43.2 (2005): 446-446.
5. Durbin, P .A. and Paterson. Reif, B.A. "Statistical theory and modeling for turbulent flows" 2nd edition, John Wiley, Chichester, U.K, 2011.
6. Kundu, Pijush K., Ira M. Cohen, and David R. Dowling. "Fluid mechanics." (1990).
7. Schlichting, H. and Gersten , K. "Boundary layer theory" 8th Edition, SpingerVerlag, 2000
8. Cebeci. T, "Modeling and computation of turbulent flows", Elsevier, Amsterdam, 2003

MOOCs:

1. NPTEL notes and lecture
   https://nptel.ac.in/courses/101/106/101106060/
2. Turbulent Flow is MORE Awesome Than Laminar Flow
   https://www.youtube.com/watch?v=5zI9sG3pjVU
3. Why 5/3 is a fundamental constant for turbulence?
   https://www.youtube.com/watch?v=_UoTTq651dE

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Understand the nature of turbulence and its origin, then with the applications of tensors in the Navier-Stokes equations.
CO2	Understanding the Taylor's and kolmogrov hypothesis, scaling and the type of turbulent flows with the application of Probability and its correlations in turbulent flows.
CO3	Deriving RANS equation for turbulent flows from the fundamental NS equation and understanding modelling, analogies and the dynamics of vortex and turbulence.
CO4	Understanding the physics of wall bounded flows, Reynolds stress and boundary layer equations for turbulent flows along with logarithmic law of the wall for modelling the wall bounded turbulent flows.
CO5	Understanding the fundamental and advanced modelling of turbulent flows from RANS equation and its application with CFD.

Scheme of Examination (SEE): Answer five full questions selecting one from each unit. To set one question each from Unit 1, 2, & 4 and two questions each from Units 3 & 5.

COURSE		CREDITS			MARKS	
NAME	FINITE ELEMENT METHOD	L	T	P	CIE	SEE
CODE	20AE6DE FEM	3	0	0	50	50

PRE-REQUISITES:
1. Solid Mechanics
2. Engineering Mathematics

UNIT-I

Review of theory of elasticity – Stresses and strains, Failure criteria – maximum normal, maximum shear and von-Mises stresses, Equilibrium equations, strain displacement relationships, general 3-D stresses, plane stress & plane strain conditions.

Concepts of numerical methods - Potential energy and equilibrium, Rayleigh-Ritz method.

Historical background of FEM, aerospace applications, Basic Steps in Finite Element Method, Assembly Procedure, Boundary and Constraint Conditions, comparison with other methods of analysis, commercial FE software.

9 hours

UNIT-II

One dimensional problems: Bar element formulation, Bars of uniform and varying cross section, element division, Numbering Scheme, Coordinate and Shape Functions, Assembly of Global Stiffness matrix, Properties of stiffness matrix, Load Vector, Treatment of Boundary Conditions, temperature effects, Numericals.

7 hours

UNIT-III

Trusses & Beams: Local and Global co-ordinate systems, Trusses – assumptions, formulation of Truss element, Hermite functions, formulation of beam. Numericals on Trusses and beams.

7 hours

UNIT-IV

Two dimensional formulation: Triangular and quadrilateral elements. Introduction to axisymmetric formulation (No formulations), Convergence criteria-requirements, Displacement models and shape functions for Higher order elements in triangular, quadrilateral elements (no formulations).

Lagrangian and serendipity elements. Iso-parametric, sub-parametric and super-parametric elements.

7 hours

UNIT-V

Heat Transfer Problems: Steady state heat transfer, 1-D heat conduction governing equation, boundary conditions, One dimensional element, 1-D heat transfer in thin fins-Numericals.

Dynamic Analysis: Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis of bar.

9 hours

TEXT BOOKS:

1. Introduction to Finite Elements in Engineering, T. R. Chandrupatla and A. D. Belegundu, Pearson Education India; 4th edition

2. The Finite Element Method in Engineering, S.S. Rao, Butterworth-Heinemann; 5th edition (20 December 2010)

REFERENCE BOOKS:

1. Finite Element Procedures. Bathe, K. J., Cambridge, 2007. ISBN: 9780979004902.
2. Finite Element Method, J.N.Reddy, McGraw –Hill International Edition.
3. Finite Element Methods, by Daryl. L. Logon, Thomson Learning 3rd edition, 2001.
4. Finite Element Analysis, C.S.Krishnamurthy,–Tata McGraw Hill Publishing Co. Ltd, New Delhi, 1995.
5. Text book of Finite Element analysis, P.Seshu–Prentice Hall of India.

MOOCs

1. Finite Element Method (FEM) Analysis and Applications - https://www.edx.org/course/finite-element-method-fem-analysis-tsinghuax-70120073x
2. A Hands-on Introduction to Engineering Simulations
https://www.edx.org/course/hands-introduction-engineering-cornellx-engr2000x
3. http://nptel.ac.in/courses/112104115/
4. https://www.coursetalk.com/providers/mit/courses/finite-element-analysis-of-solids-and-fluids-i
5. https://online-learning.tudelft.nl/courses/linear-modeling-fem/

COURSE OUTCOMES:

Upon completion of this course, student will be able to:

CO1	Apply basics of Theory of Elasticity to continuum problems.
CO2	Make use of finite elements method to bar elements for linear static structural analysis.
CO3	Formulate finite elements like truss and beam elements for linear static structural analysis.
CO4	Develop models for 2D and axisymmetric finite elements and 1D heat transfer.
CO5	Solve problems of 1D heat transfer and dynamics analysis of bar domain.

Scheme of Examination (SEE):

Answer five full questions selecting one from each unit. To set one question each from Unit 1, 2, & 3 and two questions each from Units 4 & 5.

COURSE		CREDITS			MARKS	
NAME	HYPERSONIC AEROTHERMODYNAMICS	L	T	P	CIE	SEE
CODE	20AE6DE HAT	3	0	0	50	50

Course Learning Objectives:

1. To outline and understand all the basic theoretical and practical aspects of hypersonic flows.
2. To conceptually understand the fundamental principle of equilibrium and non-equilibriumprocesses in gas.
3. To get the understanding of various flow theories for inviscid and viscous hypersonic flows.
4. To familiarize with experimental facilities and measurement techniques in hypersonics.

Prerequisites –
Aero-Thermodynamics, Aero-Fluid Mechanics, Advanced Aerodynamics

Unit 1 – 7 Hrs

The Hypersonic/Hypervelocity Aerothermodynamics Environment

Physical characteristics of hypersonic flows: Thin Shock Layers, Entropy Layer, Viscous Interaction, High-Temperature Flows, Low-Density Flow. Engineering applications: Re-entry spacecrafts, inter- continental ballistic missiles, hypersonic cruise aircrafts. Materials for Hypersonic/Hypervelocity Vehicles. Distinguished flight conditions leading to hypersonic flow phenomena.
Introduction to equilibrium and non-equilibrium flows, transport properties: viscosity, thermal conductivity, mass diffusivity, computation models. Conservation equations and species transport equation.

Unit 2 – 7 Hrs

Inviscid Hypersonic Flow Theories

Hypersonic Shock and Expansion-Wave Relations, Similarity Parameter, Newtonian theory, Newton-Busemann centrifugal corrections, Tangent-Wedge Tangent-Cone methods, Shock-Expansion method. Approximate Methods: Small-Disturbance theory, Blast-Wave Theory, Thin Shock-Layer Theory.
Exact Methods: Method of Characteristics, Shock-Shock Interactions.
Blunt body flow: Bow shock stand-off distance, Shock layer and Entropy layer.

Unit 3 – 7 Hrs

Viscous Hypersonic Flow Theories

Governing equations for viscous flow: Navier-Stokes Equations, Similarity parameters and boundary conditions, Boundary-Layer Equations for Hypersonic Flow, Hypersonic transition, Aerodynamic Heating, Entropy-Layer effects on aerodynamic heating.
Shock-Wave/Boundary-Layer Interaction. Introduction to CFD solutions of Hypersonic Viscous Flows.

Unit 4 – 7 Hrs

High Speed Thermo-Chemical Effects:

Non-calorically and non-thermally perfect effects at high flight speeds. Air dissociation, ionization and vibrational excitation. Chemical and vibrational non-equilibrium effects.

Unit 5 – 7 HrsExperimental Facilities and Measurement Techniques

Compressible flow facilities – Wind Tunnels, Shock Tunnels, Free-Piston Shock Tunnels.Measurement Techniques – Pitot tubes, pressure sensors, thermocouples.

Flow Visualization Techniques – Schlieren, Shadowgraph, Particle Image Velocimetry (PIV),Interferometry.

Course Outcomes:

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

CO1: Apprehend the important aerothermodynamics features distinguishing hypersonic flow regime. **CO2:** Utilize the basic equations of equilibrium and non-equilibrium flows specific to hypersonic flow regime.

CO3: Determine the significant hypersonic flow properties using basic governing equations for inviscid and viscous flow regimes.

CO4: Apply the knowledge and simulate the near realistic hypersonic/hypervelocity flow fields in the in the ground based experimental facilities.

Text Books:

J. D. Anderson Jr. (2006), **Hypersonic and High Temperature Gas Dynamics, 2nd Edition,** AIAAEducation Series, USA.

John J Bertin (1994). **Hypersonic Aerothermodynamics**, AIAA Education Series, USA.

Reference Books:

Ethirajan Rathakrishnan (2015). **High Enthalpy Gas Dynamics**, John Wiley & Sons Singapore Pte. Ltd. Wallace D. Hayes and Ronald F. Probstein (1959). **Hypersonic Flow Theory**, Academic Press, New York.Emst Heinrich Hirschel (2015) **Basics of Aerothermodynamics, 2nd Edition**, Springer InternationalPublishing AG Switzerland.

Online Web References:

https://nptel.ac.in/courses/101/103/101103003/

https://www.youtube.com/playlist?list=PL04kBjbWQWOPYBfbw2zqnMbWHNjU3MDYB

COURSE		CREDITS			MARKS	
NAME	FATIGUE AND FRACTURE MECHANICS	L	T	P	CIE	SEE
CODE	20AE6IE FFM	3	0	0	50	50

Course Objectives:

1. To teach the fatigue of structures & its characteristics under external load
2. To train the students for fatigue life calculation of structures under external load at variable amplitude loading
3. To instruct the mechanics of fracture to study crack growth in materials and predict the fatigue crack growth of a component using fracture mechanics
4. To instruct the modern design philosophy

Course Pre-requisites:

Basic course on Strength of Materials

Unit-1

Introduction - Introduction to Fatigue, Definition, Historical overview of fatigue, Phases in fatigue life - crack initiation, crack growth, final fracture (Micro/macro aspects of fatigue of metals).

Fatigue of Structures I - Stress Life (S-N) approach – Introduction, S-N Curves, Endurance limit, Effect of Mean stress and Haigh diagrams, Life estimation with the S-N Approach Design of Components - Goodman, Gerber and Soderberg relations and diagrams. Notches, Stress concentration factors, Notched S-N curves.

Unit-2

Fatigue of Structures II - Strain Life (ε-N) approach – Introduction, Material behaviour - monotonic stress-strain behaviour, cyclic stress strain behaviour, transient behaviour (cyclic strain hardening and softening), cyclic stress-strain curve determination, Stress-plastic strain power law relation, Strain life curve (Coffin-Manson relation), Neuber's rule.

Unit-3

Statistical Aspects of Fatigue Behaviour - Low cycle and high cycle fatigue, Transition life, Cycle counting techniques, Definition of fatigue damage, Cumulative damage, Miner's theory, other theories.

Unit-4

Fracture Mechanics – Introduction, Strength of cracked bodies, Linear Elastic Fracture Mechanics (LEFM), Griffith's theory, Irwin extension of Griffith's theory to ductile materials, Stress intensity factor, Stress analysis of cracked bodies, Relation between G & K, Crack tip plasticity, Effect of crack tip plasticity on G, Fracture toughness, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries. Fatigue crack growth curve, Empirical relation describing crack growth law-life calculations.

Unit-5

Fatigue Design and Testing - Evolution of design philosophies - Safe life, Fail-safe, Damage tolerance, Introduction to Fatigue & Damage Tolerance evaluation, recommended practices to improve fatigue design.

Text Books:

1. Elementary Engineering Fracture Mechanics, D. Broek, Noordhoff International Publishing Co., London, 1994.
2. Metal fatigue in Engineering, Ralph I Stephens, Ali Fatemi, Robert, A Wiely - Interscience, 2nd Edition, 2001.
3. Fundamentals of Fracture Mechanics, J. F. Knott, Butterworth & Co., (Publishers) Ltd., London, 1983.

Reference Books:

1. Fatigue of Aircraft Structures, W. Barrois and L. Ripley, Pergamon Press, Oxford, 1983.
2. Mechanics of Fracture, C. G. Sih, Vol.1, Sijthoff and Noordhoff International Publishing Co., Netherland, 1989
3. Fatigue of structures & materials, Jaap Schijive, Kluwer Academic Publishers, 2004
4. Deformation and Fracture Mechanics of Engineering Materials, Richard W. Hertzberg, John Wiely & Sons, 1996 4th Edition
5. Fracture Mechanics – Fundamentals & Applications, T. L. Anderson, Taylor & Francis Group, 3rd Edition 2005
6. Fundamentals of Metal Fatigue Analysis, Julie A Bannantine, Jess J Comer & James, Prentice-Hall, Inc, New Jersey, 1990

Course outcomes: After completion of the course students will be able to

CO1: Analyse fatigue of structures & its characteristics under external load.
CO2: Solve fatigue life of structures undergoing plastic behavior under external load at variable amplitude loading.
CO3: Describe the mechanics of fracture to study crack growth in materials Predict the fatigue crack growth of a component using fracture mechanics.
CO4: Identifying modern design philosophy.