AFFILIATED INSTITUTIONS

ANNA UNIVERSITY : : CHENNAI

REGULATIONS - 2009

CURRICULUM

M.E. AERONAUTICAL ENGINEERING

SEMESTER I

SL.No.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1	MA 9322	Applied Mathematics for Aeronautical Engineering	3	1	0	4
2	AE 9311	Aerodynamics	3	1	0	4
3	AE 9312	Aircraft Structures	3	1	0	4
4	AE 9313	Aerospace Propulsion	3	1	0	4
5	AE 9314	Theory of Vibrations	3	0	0	3
6	E1	Elective I	3	0	0	3
PRACTICAL						
7	AE 9315	Structures Laboratory	0	0	4	2
		TOTAL	**18**	**4**	**4**	**24**

LIST OF ELECTIVES

S.NO	COURSE CODE	COURSE TITLE	L	T	P	C
1.	AE 9001	Experimental Stress Analysis	3	0	0	3
2.	AE 9002	Numerical Heat Transfer	2	0	2	3
3.	AE 9003	Boundary Layer Theory	3	0	0	3
4.	AE 9004	Aircraft Design	2	0	2	3
5.	AE 9005	Industrial Aerodynamics	3	0	0	3
6.	AE 9006	Helicopter Aerodynamics	3	0	0	3
7.	AE 9007	Theory of Plates and Shells	3	0	0	3
8.	AE 9008	Structural Dynamics	3	0	0	3
9.	AE 9009	Aero elasticity	3	0	0	3
10.	AE 9010	High Temperature Problems in Structures	3	0	0	3
11.	AE 9011	Fatigue and Fracture Mechanics	3	0	0	3
12.	AE 9012	Theory of Elasticity	3	0	0	3
13.	AE 9013	Hypersonic Aerodynamics	3	0	0	3
14.	AE 9014	High Temperature Gas Dynamics	3	0	0	3
15.	AE 9015	Advanced Propulsion Systems	3	0	0	3
16.	AE 9016	Experimental Methods in Fluid Mechanics	3	0	0	3
17.	AE 9017	Wind Engineering	3	0	0	3
18.	AE 9018	Wind Tunnel Techniques	3	0	0	3
19.	AE 9019	Rocketry and Space Mechanics	3	0	0	3
20.	AE 9020	Composite Materials and Structures	3	0	0	3

MA 9322	APPLIED MATHEMATICS FOR AERONAUTICAL ENGINEERING	L T P C 3 1 0 4

AIM:

To make available the advanced concepts of Engineering Mathematics to the engineers and to provide the necessary mathematical skills that are needed in modeling physical processes.

OBJECTIVE:

The engineers will have an exposure on various topics such as Matrix Theory, Calculus of Variations, Differential equations, Interpolation and Integration and Linear Programming problems to understand their applications in engineering problems.

UNIT I MATRIX THEORY 12

Eigen values using QR transformations – generalized eigenvectors – canonical forms – singular value decomposition and applications – pseudo inverse – least square approximations

UNIT II DIFFERENTIAL EQUATIONS – NONLINEAR ORDINARY DIFFERENTIAL & PARTIAL DIFFERENTIAL EQUATIONS 12

Introduction – Equations, with separable variables – Equations reducible to linear form – Bernoulli's equation – Riccati's equation – Special forms of Riccati's equation – Laplace transform methods for one dimensional wave equation – Displacement in a long string – Longitudinal vibration of an elastic bar.

UNIT III CALCULUS OF VARIATION 12

Introduction – Euler's equation – several dependent variables Lagrange's equations of Dynamics – Integrals involving derivatives higher than the first – Problems with constraints – Direct methods and eigen value problems.

UNIT IV INTERPOLATION AND INTEGRATION 12

Hermite's Interpolation – Cubic Spline Interpolation – Gaussian Qundraline – Cubature.

UNIT V LINEAR PROGRAMMING PROBLEM 12

Simplex algorithm – Two phase and Big M Techniques – Duality theory – Dual simplex method – Integer programming

L : 45 T:15 TOTAL NUMBER OF PERIODS: 60

TEXT BOOKS

1. Stephenson, G, Radmore, P.M., Advanced Mathematical Methods for Engineering and Science students, Cambridge University Press 1999.
2. Bronson, R., Matrix Operations, Schaum's outline series, McGraw Hill, New York, 1989.
3. Kreyszig,E., Advanced Engineering Mathematics, John Wiley, 8th Edition, 2004.

REFERENCES

1. Froberg, C.E. Numerical Mathematics, The Benjaminn/Cummings Pulblishing Co., Inc., 1985.
2. Jain, M.K., Iyengar, S.R.K., and Jain, R.K., Numerical Methods for Scientific & Engineering computation, Wiley Eastern Ltd., 1987.
3. Gupta, A.S. Calculus of Variations with Applications, Prentice Hall of India Pvt. Ltd., New Delhi, 1997.
4. Sankara Rao, K., Introduction to Partial Differential Equations, Prentice Hall of India Pvt Ltd., New Delhi 1997.
5. Boyce & DiPrima, Elementary Differential Equations and Boundary value problems, with ODE Architect CD, 8th Edition, 2005.

AE 9311 AERODYNAMICS L T P C
3 1 0 4

OBJECTIVE

To understand the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.

UNIT I INTRODUCTION TO AERODYNAMICS 15

Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Continuity and Momentum equations, Point source and sink, doublet, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocity distributions on bodies with and without circulation in ideal and real fluid flows, Magnus effect

UNIT II INCOMPRESSIBLE FLOW THEORY 12

Conformal Transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, lifting line theory

UNIT III COMPRESSIBLE FLOW THEORY 13

Compressibility, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, small perturbation theory, Prandtl- Glauert Rule, Linearised supersonic flow, Method of characteristics

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 8

Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes

UNIT V VISCOUS FLOW AND FLOW MEASUREMENTS 12

Basics of viscous flow theory – Boundary Layer – Displacement, momentum and Energy Thickness – Laminar and Turbulent boundary layers – Boundary layer over flat plate – Blasius Solution - Types of wind tunnels – Flow visualization processes – Measurement of force and moments in wind tunnels.

L : 45 T : 15 - TOTAL NUMBER OF PERIODS : 60

TEXT BOOKS

1. J.D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985.
2. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 1995.

REFERENCES

1. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.
2. E.L. Houghton and N.B. Caruthers, Aerodynamics for Engineering Students, Edward Arnold Publishers Ltd., London (First Indian Edition), 1988
3. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989.
4. W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications, 1984.

AE 9312 AIRCRAFT STRUCTURES L T P C
3 1 0 4

OBJECTIVE

To study different types of beams and columns subjected to various types of loading and support conditions with particular emphasis on aircraft structural components.

UNIT I BENDING OF BEAMS 12

Elementary theory of bending - Introduction to semi-monocoque structures - Bredt-Batho theory - Stresses in beams of symmetrical and unsymmetrical sections -Box beams – General formula for bending stresses- principal axes method – Neutral axis method.

UNIT II SHEAR FLOW IN OPEN SECTIONS 9

Shear stresses in beams – Shear flow in stiffened panels - Shear flow in thin walled open tubes – Shear centre – Shear flow in open sections with stiffeners.

UNIT III SHEAR FLOW IN CLOSED SECTIONS 15

Shear flow in closed sections with stiffeners– Angle of twist - Shear flow in two flange and three flange box beams – Shear centre - Shear flow in thin walled closed tubes - Torsional shear flow in multi cell tubes - Flexural shear flow in multi cell stiffened structures.

UNIT IV STABILITY PROBLEMS 12

Stability problems of thin walled structures– Buckling of sheets under compression, shear, bending and combined loads - Crippling stresses by Needham's and Gerard's methods–Sheet stiffener panels-Effective width, Inter rivet and sheet wrinkling failures-Tension field web beams(Wagner's).

UNIT V ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS 12

Loads on Wings – Schrenk's curve - Shear force, bending moment and torque distribution along the span of the Wing. Loads on fuselage - Shear and bending moment distribution along the length of the fuselage. Analysis of rings and frames.

L : 45, T : 15, TOTAL NUMBER OF PERIODS: 60

TEXT BOOKS

1. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
2. Megson, T.M.G; Aircraft Structures for Engineering Students, Edward Arnold, 1995.

REFERENCES

1. Peery, D.J. and Azar, J.J., Aircraft Structures, 2nd Edition, McGraw-Hill, New York, 1993.
2. Stephen P. Tinnoshenko & S.woinowsky Krieger, Theory of Plates and Shells, 2nd Edition, McGraw-Hill, Singapore, 1990.
3. Rivello, R.M., Theory and Analysis of Flight structures, McGraw-Hill, N.Y., 1993

AE 9313 AEROSPACE PROPULSION L T P C
3 1 0 4

OBJECTIVE

To understand the principles of operation and design of aircraft and spacecraft power plants.

UNIT I ELEMENTS OF AIRCRAFT PROPULSION 12

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

UNIT II PROPELLER THEORY 12

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

UNIT III INLETS, NOZZLES AND COMBUSTION CHAMBERS 12

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

UNIT IV COMPRESSORS AND TURBINES 12

Centrifugal compressor – Work done and pressure rise – Velocity diagrams – Elementary theory of axial flow compressor – degree of reaction – Impulse and reaction gas turbines – Velocity triangles – Choice of blade profile, pitch and chord.

UNIT V ROCKET PROPULSION 12

Introduction to rocket propulsion – Reaction principle – Thrust equation – Classification of rockets based on propellants used – solid, liquid and hybrid – Comparison of these engines with special reference to rocket performance – Thrust control in liquid rockets.

L : 45, T :15 – TOTAL NUMBER OF PERIODS : 60

TEXT BOOKS

1. Hill,P.G. and Peterson, C.R. Mechanics and Thermodynamics of Propulsion, Addison – Wesley Longman Inc. 1999
2. Cohen, H. Rogers, G.F.C. and Saravanamuttoo,H.I.H, Gas Turbine Theory, Longman,1989

REFERENCES

1. G.C. Oates, “Aerothermodynamics of Aircraft Engine Components”, AIAA Education Series, 1985.
2. G.P.Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 5th Edition, 1986.
3. W.P.Gill, H.J.Smith & J.E. Ziurys, “Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants”, Oxford & IBH Publishing Co., 1980.

AE 9314 THEORY OF VIBRATIONS L T P C
3 0 0 3

OBJECTIVE

To study the dynamic behaviour of different aircraft components and the interaction among the aerodynamic, elastic and inertia forces

UNIT I SINGLE DEGREE OF FREEDOM SYSTEMS 8

Simple harmonic motion, definition of terminologies, Newton’s Laws, D’Alembert’s principle, Energy methods. Free vibrations, free damped vibrations, and forced vibrations with and without damping, base excitation, and vibration measuring instruments.

UNIT II MULTI-DEGREES OF FREEDOM SYSTEMS 12

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

UNIT III VIBRATION OF ELASTIC BODIES 10

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

UNIT IV EIGEN VALUE PROBLEMS & DYNAMIC RESPONSE OF LARGE SYSTEMS 10

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

UNIT V ELEMENTS OF AEROELASTICITY 5

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

L : 45, TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. Timoshenko, S. "Vibration Problems in Engineering", John Wiley & Sons, Inc., 1987.
2. Meirovitch, L. "Elements of Vibration Analysis", McGraw-Hill Inc., 1986.
3. Thomson W.T, Marie Dillon Dahleh, "Theory of Vibrations with Applications", Prentice Hall, 1997

REFERENCES

1. F.S. Tse., I.F. Morse and R.T. Hinkle, "Mechanical Vibrations", Prentice-Hall of India, 1985.
2. Rao.J.S. and Gupta.K. "Theory and Practice of Mechanical Vibrations", Wiley Eastern Ltd., New Delhi, 1999.
3. Fung, Y.C., "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 1985.

AE 9315	STRUCTURES LABORATORY	L T P C 0 0 4 2

OBJECTIVE

To experimentally study the unsymmetrical bending of beams, find the location of shear centre , obtain the stresses in circular discs and beams using photoelastic techniques, calibration of photo – elastic materials and study on vibration of beams.

LIST OF EXPERIMENTS

1. Constant strength Beams
2. Buckling of columns
3. Unsymmetrical Bending of Beams
4. Shear Centre Location for Open Section
5. Shear Centre Location for Closed Section
6. Flexibility Matrix for Cantilever Beam
7. Combined Loading
8. Calibration of Photo Elastic Materials
9. Stresses in Circular Disc Under Diametrical Compression – Photo Elastic Method
10. Vibration of Beams with Different Support Conditions
11. Determination of elastic constants of a composite laminate.
12. Wagner beam

TOTAL NUMBER OF PERIODS: 60

LABORATORY EQUIPMENTS REQUIREMENTS

1. Constant strength beam setup
2. Column setup
3. Unsymmetrical Bending setup
4. Experimental setup for location of shear centre (open & close section)
5. Cantilever beam setup
6. Experimental setup for bending and torsional loads
7. Diffuser transmission type polariscope with accessories
8. Experimental setup for vibration of beams
9. Universal Testing Machine
10. Wagner beam setup

AE 9001 EXPERIMENTAL STRESS ANALYSIS L T P C
3 0 0 3

OBJECTIVE

To bring awareness on experimental method of finding the response of the structure to different types of load.

UNIT I INTRODUCTION 8

Principle of measurements-Accuracy, sensitivity and range- Mechanical, Optical, Acoustical and Electrical extensometers.

UNIT II ELECTRICAL RESISTANCE STRAIN GAUGES 12

Principle of operation and requirements-Types and their uses-Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity-Rosette analysis-Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements-Strain indicators.

UNIT III PRINCIPLES OF PHOTOELASTICITY 9

Two dimensional photo elasticity-Concepts of photoelastic effects-Photoelastic materials-Stress optic law-Plane polariscope–Circular polariscope-Transmission and Reflection type-Effect of stressed model in Plane and Circular polariscope. Interpretation of fringe pattern Isoclinics and Isochromatics.-Fringe sharpening and Fringe multiplication techniques-Compensation and separation techniques-Introduction to three dimensional photoelasticity.

UNIT IV PHOTOELASTICITY AND INTERFEROMETRY TECHNIQUES 9

Fringe sharpening and Fringe multiplication techniques-Compensation and separation techniques-Calibration methods –Photo elastic materials. Introduction to three dimensional photoelasticity. Moire fringes – Laser holography – Grid methods-Stress coat

UNIT V NON DESTRUCTIVE TECHNIQUES 7

Radiography- Ultrasonics- Magnetic particle inspection- Fluorescent penetrant technique-Eddy current testing- Acoustic emission technique.

L : 45, TOTAL : 45

TEXT BOOKS

1. J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New York, 1988.
2. Srinath,L.S., Raghava,M.R., Lingaiah,K. Gargesha,G.,Pant B. and Ramachandra,K. – Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984
3. P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.

REFERENCES

1. M. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.
2. G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.
3. A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

AE 9002 **NUMERICAL HEAT TRANSFER** **L T P C**
2 0 2 3

OBJECTIVE

To introduce the concepts of heat transfer to enable the students to design components subjected to thermal loading.

UNIT I BASICS OF HEAT TRANSFER 6

Basic review of heat transfer –Conduction Convection -Radiation– Aerospace problems- Application of numerical methods

UNIT II CONDUCTIVE HEAT TRANSFER 6

Conduction – Convection systems – Numerical treatment of 1-D and 2-D heat conduction – Problems in Cartesian and polar coordinate systems – *conduction with heat generation* - Heat transfer problems in infinite and semi infinite solids – 1-D Transient analysis

UNIT III CONVECTIVE HEAT TRANSFER 6

Convection- Numerical treatment of steady 1-D and 2-d heat convection-diffusion steady-unsteady problems- Computation of thermal boundary layer flows-Transient free convection from a heat vertical plate

UNIT IV RADIATIVE HEAT TRANSFER 6

Radiation- Numerical treatment of radiation problems- transient mixed convection and radiation from a vertical fin.

UNIT V SPECIAL PROBLEMS IN AEROSPACE ENGINEERING 6

Heat transfer problem in gas turbine combustion chamber-ablative heat transfer-Aerodynamic heating-Moving boundary problems - Numerical treatment.

PRACTICALS

Developing a numerical code for 1D, 2D heat transfer problems. **30**

L : 30, P : 30 - TOTAL NUMBER OF PERIODS: 60

TEXT BOOKS

1. P. S. Ghoshdasidar , “Computer simulation of low and Heat transfer” McGraw-Hill Book Co., Inc., New Delhi, 1998.
2. Yunus A. Cengel, Heat Transfer – A Practical Approach Tata McGraw Hill Edition, 2003
3. S.C. Sachdeva, “Fundamentals of Engineering Heat & Mass Transfer”, Wiley Eastern Ltd., New Delhi, 1981.

REFERENCES

1. John H. Lienhard, “A Heat Transfer Text Book”, Prentice Hall Inc., 1981.
2. J.P. Holman, “Heat Transfer”, McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.
3. John D. Anderson, JR” Computational Fluid Dynamics”, McGraw-Hill Book Co., Inc., New York, 1995.
4. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
5. C.Y.Chow, “Introduction to Computational Fluid Dynamics”, John Wiley, 1979.

AE 9003 **BOUNDARY LAYER THEORY** **L T P C**
3 0 0 3

UNIT I VISCOUS FLOW EQUATIONS 9

Navier-Stokes Equations, Creeping motion, Couette flow, Poiseuille flow through ducts, Ekman drift.

UNIT II LAMINAR BOUNDARY LAYER 9

Development of boundary layer – Estimation of boundary layer thickness, Displacement thickness - Momentum and energy thicknesses for two dimensional flow – Two dimensional boundary layer equations – Similarity solutions - Blasius solution.

UNIT III TURBULENT BOUNDARY LAYER 9

Physical and mathematical description of turbulence, two-dimensional turbulent boundary layer equations, Velocity profiles – Inner, outer and overlap layers, Transition from laminar to turbulent boundary layers, turbulent boundary layer on a flat plate, mixing length hypothesis.

UNIT IV APPROXIMATE SOLUTION TO BOUNDARY LAYER EQUATIONS 9

Approximate integral methods, digital computer solutions – Von Karman – Polhausen method.

UNIT V THERMAL BOUNDARY LAYER 9

Introduction to thermal boundary layer – Heat transfer in boundary layer - Convective heat transfer, importance of non dimensional numbers – Prandtl number, Nusselt number, Lewis number etc.

L : 45 - TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. H. Schlichting, “Boundary Layer Theory”, McGraw-Hill, New York, 1979.
2. Frank White – Viscous Fluid flow – McGraw Hill, 1998

REFERENCES

1. A. J. Reynolds, “Turbulent flows in Engineering”, John Wiley & Sons, 1980.
2. Ronald L., Panton, “Incompressible fluid flow”, John Wiley & Sons, 1984.
3. Tuncer Cebeci and Peter Bradshaw, “Momentum transfer in boundary layers”, Hemisphere Publishing Corporation, 1977.

AE 9004 **AIRCRAFT DESIGN** **L T P C**
2 0 2 3

OBJECTIVE

To introduce and develop the basic concept of aircraft design.

Each student is assigned the design of an Airplane (or Helicopter or any other flight vehicle), for given preliminary specifications. The following are the assignments to be carried out:

UNIT I REVIEW OF DEVELOPMENTS IN AVIATION 6

Categories and types of aircrafts – various configurations – Layouts and their relative merits – strength, stiffness, fail safe and fatigue requirements – Manoeuvering load factors – Gust and manoeuverability envelopes – Balancing and maneuvering loads on tail planes.

UNIT II POWER PLANT TYPES AND CHARACTERISTICS 6

Characteristics of different types of power plants – Propeller characteristics and selection – Relative merits of location of power plant.

UNIT III PRELIMINARY DESIGN 6

Selection of geometric and aerodynamic parameters – Weight estimation and balance diagram – Drag estimation of complete aircraft – Level flight, climb, take – off and landing calculations – range and endurance – static and dynamic stability estimates – control requirements.

UNIT IV SPECIAL PROBLEMS 6

Layout peculiarities of subsonic and supersonic aircraft – optimisation – of wing loading to achieve desired performance – loads on undercarriages and design requirements.

UNIT V STRUCTURAL DESIGN 6

Estimation of loads on complete aircraft and components – Structural design of fuselage, wings and undercarriages, controls, connections and joints. Materials for modern aircraft – Methods of analysis, testing and fabrication.

PRACTICALS

Conceptual design of an aircraft for given specifications. **30**

L : 30, P : 30 – TOTAL NUMBER OF PERIODS : 60

TEXT BOOKS

1. D.P. Raymer, “Aircraft conceptual design”, AIAA Series, 1988.
2. G. Corning, “Supersonic & Subsonic Airplane Design”, II Edition, Edwards Brothers Inc., Michigan, 1953.
3. E.F. Bruhn, “Analysis and Design of Flight Vehicle Structures”, Tristate Offset Co., U.S.A., 1980.

REFERENCES

1. E. Torenbeek, “Synthesis of Subsonic Airplane Design”, Delft University Press, London, 1976.
2. H.N.Kota, Integrated design approach to Design fly by wire” Lecture notes Interline Pub. Bangalore, 1992.
3. A.A. Lebedenski, “Notes on airplane design”, Part-I, I.I.Sc., Bangalore, 1971.

AE 9005 INDUSTRIAL AERODYNAMICS L T P C
3 0 0 3

OBJECTIVE:
To familiarize the learner with non-aeronautical uses of aerodynamics such as road vehicle, building aerodynamics and problems of flow induced vibrations.

UNIT I ATMOSPHERE 9
Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on gradient height, Structure of turbulent flows.

UNIT II WIND ENERGY COLLECTORS 9
Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory.

UNIT III VEHICLE AERODYNAMICS 9
Power requirements and drag coefficients of automobiles, Effects of cut back angle, Aerodynamics of trains and Hovercraft.

UNIT IV BUILDING AERODYNAMICS 9
Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, Special problems of tall buildings, Building codes, Building ventilation and architectural aerodynamics.

UNIT V FLOW INDUCED VIBRATIONS 9
Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall flutter.

L : 45, TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. M.Sovran (Ed), “Aerodynamics and drag mechanisms of bluff bodies and road vehicles”, Plenum press, New York, 1978.
2. P. Sachs, “Winds forces in engineering”, Pergamon Press, 1978.

REFERENCES

1. R.D. Blevins, “Flow induced vibrations”, Van Nostrand, 1990.
2. N.G. Calvent, “Wind Power Principles”, Charles Griffin & Co., London, 1979.

AE 9006 **HELICOPTER AERODYNAMICS** **L T P C**
3 0 0 3

OBJECTIVE:
To present the basic ideas of evolution, performance and associated stability problems of helicopter.

UNIT I INTRODUCTION 7
Types of rotorcraft – autogiro, gyrodyne, helicopter, Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti torque pedals.

UNIT II HELICOPTER AERODYNAMICS 12
Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, vortex theory, rotor in hover, rotor model with cylindrical wake and constant circulation along blade, free wake model, Constant chord and ideal twist rotors, Lateral flapping, Coriolis forces, reaction torque, compressibility effects, Ground effect.

UNIT III PERFORMANCE 9
Hover and vertical flight, forward level flight, Climb in forward flight, optimum speeds, Maximum level speed, rotor limits envelope – performance curves with effects of altitude

UNIT IV STABILITY AND CONTROL 9
Helicopter Trim, Static stability – Incidence disturbance, forward speed disturbance, angular velocity disturbance, yawing disturbance, Dynamic Stability.

UNIT V AERODYNAMIC DESIGN 8
Blade section design, Blade tip shapes, Drag estimation – Rear fuselage upsweep

L : 45, TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. J. Seddon, " Basic Helicopter Aerodynamics", AIAA Education series, Blackwell scientific publications, U.K, 1990.
2. A. Gessow and G.C.Meyers, "Aerodynamics of the Helicopter", Macmillan and Co., New York, 1982.

REFERENCES

1. John Fay, "The Helicopter", Himalayan Books, New Delhi, 1995.
2. Lalit Gupta, "Helicopter Engineering", Himalayan Books, New Delhi, 1996.
3. Lecture Notes on "Helicopter Technology", Department of Aerospace Engineering, IIT –Kanpur and Rotary Wing aircraft R&D center, HAL, Bangalore, 1998.

AE 9007 THEORY OF PLATES AND SHELLS L T P C
3 0 0 3

OBJECTIVE:
To study the behaviour of the plates and shells with different geometry under various types of loads.

UNIT I CLASSICAL PLATE THEORY 8
Classical Plate Theory – Assumptions – Differential Equations – Boundary Conditions.

UNIT II PLATES OF VARIOUS SHAPES 10
Navier's Method of Solution for Simply Supported Rectangular Plates – Levy's Method of Solution for Rectangular Plates under Different Boundary Conditions – Circular plates.

UNIT III EIGEN VALUE ANALYSIS 8
Stability and Free Vibration Analysis of Rectangular Plates.

UNIT IV APPROXIMATE METHODS 10
Rayleigh – Ritz, Galerkin Methods– Finite Difference Method – Application to Rectangular Plates for Static, Free Vibration and Stability Analysis.

UNIT V SHELLS 9
Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells.

L :45 –TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. Timoshenko, S.P. Winowsky. S., and Kreger, Theory of Plates and Shells, McGraw Hill Book Co., 1990.
2. T.K.Varadan & K. Bhaskar, "Anályis of plates – Theory and problems", Narosha Publishing Co., 1999.

REFERENCES

1. Flugge, W. Stresses in Shells, Springer – Verlag, 1985.
2. Timoshenko, S.P. and Gere, J.M., Theory of Elastic Stability, McGraw Hill Book Co. 1986.
3. Harry Kraus, 'Thin Elastic Shells', John Wiley and Sons, 1987.

AE 9008 **STRUCTURAL DYNAMICS** **L T P C**
3 0 0 3

UNIT I FORCE-DEFLECTION PROPERTIES OF STRUCTURES 10

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

UNIT II PRINCIPLES OF DYNAMICS 10

Free and forced vibrations of systems with finite degrees of freedom – Damped oscillations – D"Alembert's principle – Hamilton's principle – Lagrangean equations of motion and applications.

UNIT III NATURAL MODES OF VIBRATION 10

Equations of motion for free vibrations. Solution of Eigen value problems – Normal coordinates and orthogonality conditions of eigen vectors.

UNIT IV ENERGY METHODS 8

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

UNIT V APPROXIMATE METHODS 7

Approximate methods of evaluating the eigen values and the dynamic response of continuous systems. Application of Matrix methods for dynamic analysis.

L : 45 - TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. W.C. Hurty and M.F. Rubinstein, "Dynamics of Structures", Prentice Hall of India Pvt., Ltd., New Delhi, 1987.
2. F.S.Tse, I.E. Morse and H.T. Hinkle, "Mechanical Vibration", Prentice Hall of India Pvt., Ltd., New Delhi, 1988.

REFERENCES

1. R.K. Vierck, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.
2. S.P. Timoshenko and D.H. Young, "Vibration Problems in Engineering", John Willey & Sons Inc., 1984.
3. Von. Karman and A.Biot, "Mathematical Methods in Engineering", McGraw-Hill Book Co., New York, 1985.

AE 9009 **AERO ELASTICITY** **L T P C**
3 0 0 3

OBJECTIVE
To understand the theoretical concepts of material behaviour with particular emphasis on their elasticity property.

UNIT I AEROELASTIC PHENOMENA 6
Stability versus response problems – The aero-elastic triangle of forces – Aeroelasticity in Aircraft Design – Prevention of aeroelastic instabilities. Influence and stiffness co-efficients. Coupled oscillations.

UNIT II DIVERGENCE OF A LIFTING SURFACE 10
Simple two dimensional idealisations-Strip theory – Integral equation of the second kind – Exact solutions for simple rectangular wings – 'Semirigid' assumption and approximate solutions – Generalised coordinates – Successive approximations – Numerical approximations using matrix equations.

UNIT III STEADY STATE AEROLASTIC PROBLEMS 9
Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory and successive approximations – Lift distribution – Rigid and elastic wings. Tail efficiency. Effect of elastic deformation on static longitudinal stability.

UNIT IV FLUTTER PHENOMENON 14
Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasisteady aerodynamic derivatives. Galerkin method for critical flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter prevention and control.

UNIT V EXAMPLES OF AEROELASTIC PROBLEMS 6
Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges.

L : 45 – TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 2008.
2. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986.

REFERENCES

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
2. R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
3. R.D.Blevins, "Flow Induced Vibrations", Krieger Pub Co., 2001

AE 9010 HIGH TEMPERATURE PROBLEMS IN STRUCTURES L T P C
3 0 0 3

UNIT I TEMPERATURE EQUATIONS & AERODYNAMIC HEATING 9

For condition, radiation and convection – Fourier's equation – Boundary and initial conditions – One-dimensional problem formulations – Methods and Solutions. Heat balance equation for idealised structures – Adiabatic temperature – Variations – Evaluation of transient temperature.

UNIT II THERMAL STRESS ANALYSIS 9

Thermal stresses and strains – Equations of equilibrium – Boundary conditions – Thermoelasticity – Two dimensional problems and solutions – Airy stress function and applications.

UNIT III THERMAL STRESS IN BEAMS, TRUSSES AND THIN CYLINDERS 9

Thermal stresses in axially loaded members, beams with varying cross sections. Effect of temperature in thin cylinders.

UNIT IV THERMAL STRESSES IN PLATES 9

Membrane thermal stresses – Circular plates – Rectangular plates – Bending thermal stresses – Thick plates with temperature varying along thickness – Thermal vibration of plates.

UNIT V SPECIAL TOPICS & MATERIALS 9

Thermal bucking, Fatigue and shock applications – High temperature effects on material properties.

L : 45 - TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. A.B. Bruno and H.W. Jerome, "Theory of Thermal Stresses", John Wiley & Sons Inc., New York, 1980.
2. N.J. Hoff, "High Temperature effects in Aircraft Structures", John Wiley & Sons Inc., London, 1986.

REFERENCE

1. D.J. Johns, "Thermal Stress Analysis", Pergamon Press, Oxford, 1985.

AE 9011 FATIGUE AND FRACTURE MECHANICS L T P C
3 0 0 3

UNIT I FATIGUE OF STRUCTURES 10

S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Neuber's stress concentration factors – plastic stress concentration factors – Notched S-N curves.

UNIT II STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR 8

Low cycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Analysis of load histories – Cycle counting techniques – Cumulative damage – Miner's theory – other theories.

UNIT III PHYSICAL ASPECTS OF FATIGUE 5

Phase in fatigue life – Crack initiation – Crack growth – Final fracture – Dislocations – Fatigue fracture surfaces.

UNIT IV FRACTURE MECHANICS 15

Strength of cracked bodies – potential energy and surface energy – Griffith's theory – Irwin – Orwin extension of Griffith's theory to ductile materials – Stress analysis of cracked bodies – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries.

UNIT V FATIGUE DESIGN AND TESTING 7

Safe life and fail safe design philosophies – Importance of Fracture Mechanics in aerospace structure – Application to composite materials and structures.

L : 45 – TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. D.Brock, "Elementary Engineering Fracture Mechanics", Noordhoff International Publishing Co., London, 1994.
2. J.F.Knott, "Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London, 1983.

REFERENCES

1. W.Barrois and L.Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983.
2. C.G.Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

AE 9012 **THEORY OF ELASTICITY** **L T P C**
3 0 0 3

OBJECTIVE
To understand the theoretical concepts of material behaviour with particular emphasis on their elasticity property.

UNIT I INTRODUCTION 6
Definition, notations and sign conventions for stress and strain – Stress - strain relations, Strain-displacement relations- Elastic constants.

UNIT II BASIC EQUATIONS OF ELASTICITY 10
Equations of equilibrium – Compatibility equations in strains and stresses –Boundary Conditions - Saint-Venant's principle - Stress ellipsoid – Stress invariants – Principal stresses in 2-D and 3-D.

UNIT III 2 - D PROBLEMS IN CARTESIAN COORDINATES 9
Plane stress and plain strain problems - Airy's stress function – Biharmonic equations – 2-D problems – Cantilever and simply supported beams.

UNIT IV 2 - D PROBLEMS IN POLAR COORDINATES 12
Equations of equilibrium – Strain – displacement relations – Stress – strain relations – Airy's stress function – Axisymmetric problems - Bending of Curved Bars - Circular Discs and Cylinders – Rotating Discs and Cylinders - Kirsch, Boussinasque's and Michell's problems.

UNIT V TORSION 8
Coulomb's theory-Navier's theory-Saint Venant's Semi-Inverse method – Torsion of Circular, Elliptical and Triangular sections - Prandtl's theory-Membrane analogy.

L : 45 – TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. S.P. Timoshenko and J.N. Goodier, Theory of Elasticity, McGraw-Hill, 1985.
2. E. Sechler, "Elasticity in Engineering" John Wiley & Sons Inc., New York, 1980.

REFERENCES

1. Ugural, A.C and Fenster, S.K, Advanced Strength and Applied Elasticity, Prentice hall, 2003
2. Wang, C.T. Applied elasticity, McGraw Hill 1993
3. Enrico Volterra and Caines, J.H, Advanced strength of Materials, Prentice Hall, 1991

AE 9013 HYPERSONIC AERODYNAMICS L T P C
3 0 0 3

OBJECTIVE:
To present the basic ideas of hypersonic flow and the associated problem areas.

UNIT I BASICS OF HYPERSONIC AERODYNAMICS 8
Thin shock layers – entropy layers – low density and high density flows – hypersonic flight paths hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 9
Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS 9
Approximate methods hypersonic small disturbance equation and theory – thin shock layer theory – blast wave theory - entropy effects - rotational method of characteristics - hypersonic shock wave shapes and correlations.

UNIT IV VISCOUS HYPERSONIC FLOW THEORY 10
Navier–Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating.

UNIT V VISCOUS INTERACTIONS IN HYPERSONIC FLOWS 9
Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

L : 45 - TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS
1. John D. Anderson, Jr, Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.

REFERENCES
1. John.D.Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series.
2. William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series.
3. John T. Bertin, Hypersonic Aerothermodynamics, 1994 AIAA Inc., Washington D.C.

AE 9014 HIGH TEMPERATURE GAS DYNAMICS L T P C
3 0 0 3

UNIT I INTRODUCTION 8

Nature of high temperature flows – Chemical effects in air – Real perfect gases – Gibb's free energy and entropy by chemical and non equilibrium – Chemically reacting mixtures and boundary layers.

UNIT II STATISTICAL THERMODYNAMICS 8

Introduction to statistical thermodynamics – Relevance to hypersonic flow - Microscopic description of gases – Boltzman distribution – Cartesian function

UNIT III KINETIC THEORY AND HYPERSONIC FLOWS 9

Chemical equilibrium calculation of equilibrium composition of high temperature air – equilibrium properties of high temperature air – collision frequency and mean free path – velocity and speed distribution functions.

UNIT IV INVISCID HIGH TEMPERATURE FLOWS 10

Equilibrium and non – equilibrium flows – governing equations for inviscid high temperature equilibrium flows – equilibrium normal and oblique shock wave flows – frozen and equilibrium flows – equilibrium conical and blunt body flows – governing equations for non equilibrium inviscid flows.

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES 10

Transport coefficients – mechanisms of diffusion – total thermal conductivity – transport characteristics for high temperature air – radiative transparent gases – radiative transfer equation for transport, absorbing and emitting and absorbing gases.

L : 45 – TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. John D. Anderson, Jr., Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series, New York, 1996.
2. John D. Anderson, Jr., Modern Compressible Flow with Historical perspective McGraw-Hill Series, New York, 1996.

REFERENCES

1. William H. Heiser and David T. Pratt, Hypersonic Air breathing propulsion, AIAA Education Series.
2. John T. Bertin, Hypersonic Aerothermodynamics publishers - AIAA Inc., Washington, D.C.,1994.
3. T.K.Bose, High Temperature Gas Dynamics,

AE 9015 ADVANCED PROPULSION SYSTEMS L T P C
3 0 0 3

OBJECTIVE

To study in detail about gas turbines, ramjet, fundamentals of rocket propulsion and chemical rockets

UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS 8

Air breathing propulsion systems like Turbojet, turboprop, ducted fan, Ramjet and Air augmented rockets – Thermodynamic cycles – Pulse propulsion – Combustion process in pulse jet engines – inlet charging process – Supercritical charging and subcritical discharging – Subcritical charging and subcritical discharging – Subcritical charging and supercritical discharging.

UNIT II RAMJETS AND AIR AUGMENTED ROCKETS 8

Preliminary performance calculations – Diffuser design and hypersonic inlets – combustor and nozzle design – air augmented rockets – engines with supersonic combustion.

UNIT III SCRAMJET PROPULSION SYSTEM 12

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

UNIT IV NUCLEAR PROPULSION 9

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

UNIT V ELECTRIC AND ION PROPULSION 8

Basic concepts in electric propulsion – power requirements and rocket efficiency – thermal thrusters – electrostatic thrusters – plasma thruster of the art and future trends – Fundamentals of ion propulsion – performance analysis – electrical thrust devices – ion rocket engine.

L : 45 - TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. G.P. Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 1998.
2. William H. Heiser and David T. Pratt, Hypersonic Airbreathing propulsion, AIAA Education Series, 2001.

REFERENCES

1. Fortescue and Stark, Spacecraft Systems Engineering, 1999.
2. Cumpsty, Jet propulsion, Cambridge University Press, 2003.

AE 9016 EXPERIMENTAL METHODS IN FLUID MECHANICS L T P C
3 0 0 3

UNIT I BASIC MEASUREMENTS IN FLUID MECHANICS 8

Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization –Components of measuring systems – Importance of model studies - Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers -

UNIT II WIND TUNNEL MEASEUREMENTS 8

Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation and calibration of wind tunnels – Turbulence- Wind tunnel balance – Principle and application and uses – Balance calibration.

UNIT III FLOW VISUALIZATION AND ANALOGUE METHODS 10

Visualization techniques – Smoke tunnel – Hele-Shaw apparatus - Interferometer – Fringe-Displacement method – Shadowgraph - Schlieren system – Background Oriented Schliren (BOS) System - Hydraulic analogy – Hydraulic jumps – Electrolytic tank

UNIT IV PRESSURE, VELOCITY AND TEMPERATURE MEASUREMENTS 10

Pitot-Static tube characteristics - Velocity measurements - Hot-wire anemometry – Constant current and Constant temperature Hot-Wire anemometer – Hot-film anemometry – Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV) – Pressure Sensitive Paints - Pressure measurement techniques - Pressure transducers – Temperature measurements.

UNIT V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS 9

Data acquisition and processing – Signal conditioning - Estimation of measurement errors – Uncertainty calculation - Uses of uncertainty analysis.

L : 45 – TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. Rathakrishnan, E., “Instrumentation, Measurements, and Experiments in Fluids,” CRC Press – Taylor & Francis, 2007.

REFERENCES

1. Robert B Northrop, “Introduction to Instrumentation and Measurements”, Second Edition, CRC Press, Taylor & Francis, 2006.

AE 9017	WIND ENGINEERING	L T P C 3 0 0 3

UNIT I THE ATMOSPHERE 6

Atmospheric Circulation – Stability of atmospheres – definitions & implications – Effects of friction – Atmospheric motion – Local winds, Building codes, Terrains different types.

UNIT II ATMOSPHERIC BOUNDARY LAYER: 9

Governing Equations – Mean velocity profiles, Power law, logarithmic law wind speeds, Atmospheric turbulence profiles – Spectral density function – Length scale of turbulence, Roughness parameters simulation techniques in wind tunnels.

UNIT III BLUFF BODY AERODYNAMICS: 10

Governing Equations – Boundary layers and separations – Wake and Vortex formation two dimensional – Strouhal Numbers, Reynolds numbers – Separation and Reattachments Oscillatory Flow patterns Vortex sheding flow switching – Time varying forces to wind velocity in turbulent flow – Structures in three dimensional

UNIT IV WIND LOADING 10

Introduction, Analysis and synthesis loading coefficients, local & global coefficients pressure shear stress coefficients, force and moment coefficients – Assessment methods – Quasi steady method – Peak factor method – Extreme value method

UNIV V AEROELASTIC PHENOMENA: 10

Vortex shedding and lock in phenomena in turbulent flows, across wind galloping wake galloping - Torsional divergence, along wind galloping of circular cables, cross wind galloping of circular cables, Wind loads & their effects on tall structures – Launch vehicles

L: 45, TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. Emil Simiu & Robert H Scanlan, Wind effects on structures - fundamentals and applications to design, John Wiley & Sons Inc New York, 1996.

REFERENCES:

1. Tom Lawson Building Aerodynamics Imperial College Press London, 2001
2. N J Cook, Design Guides to wind loading of buildings structures Part I & II, Butterworths, London, 1985
3. IS: 875 (1987) Part III Wind loads, Indian Standards for Building codes.

AE 9018 **WIND TUNNEL TECHNIQUES** **L T P C**
3 0 0 3

UNIT I PRINCIPLES OF MODEL TESTING: 6
Buckingham Theorem – Non dimensional numbers – Scale effect – Geometric Kinematics and Dynamic similarities.

UNIT II WIND TUNNELS: 8
Classification – special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions – Layouts – sizing and design parameters.

UNIT III CALIBRATION OF WIND TUNNELS: 10
Test section speed – Horizontal buoyancy – Flow angularities – Turbulence measurements – Associated instrumentation – Calibration of supersonic tunnels.

UNIT IV WIND TUNNEL MEASUREMENTS: 12
Steady and Unsteady Pressure and Velocity measurements – Force measurements – Three component and six component balances – Internal balances – Principles of Hotwire Anemometer.

UNIT V FLOW VISUALIZATION: 9
Smoke and Tuft techniques – Dye injection special techniques – Optical methods of flow visualization.

L : 45 – TOTAL NUMBER OF PERIODS: 45

TEXT BOOKS

1. Rae, W.H. and Pope, A., Low Speed Wind Tunnel Testing, John Wiley Publications, 1984.
2. Pope, A., and Goin, L., High Speed Wind Tunnel Testing, John Wiley, 1985.

REFERENCES

1. P. Bradshaw, Experimental Fluid Mechanics, Pergamon Press, Macmillan Co., New York, 1964.

AE 9019 ROCKETRY AND SPACE MECHANICS L T P C
3 0 0 3

OBJECTIVE
To introduce basic concepts of design and trajectory estimation of rockets and missiles.

UNIT I ORBITAL MECHANICS 9
Description of solar system – Kepler's Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobi's Integral, Librations points - Estimation of orbital and escape velocities

UNIT II SATELLITE DYNAMICS 9
Geosynchronous and geostationary satellites life time – satellite perturbations – Hohmann orbits – calculation of orbit parameters – Determination of satellite rectangular coordinates from orbital elements

UNIT III ROCKET MOTION 10
Principle of operation of rocket motor - thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravity turn trajectories determinations of range and altitude – simple approximations to burnout velocity – staging of rockets.

UNIT IV ROCKET AERODYNAMICS 9
Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – conical and bell shaped nozzles – adapted nozzles – rocket dispersion – launching problems.

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 8
Need for multistaging of rocket vehicles – multistage vehicle optimization – stage separation dynamics and separation techniques- aerodynamic and jet control methods of rocket vehicles - SITVC.

L : 45, TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. G.P. Sutton, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edition, 1986.
2. J.W. Cornelisse, "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd., London, 1982.

REFERENCES

1. Van de Kamp, "Elements of astromechanics", Pitman Publishing Co., Ltd., London, 1980.
2. E.R. Parker, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982.

AE 9020 COMPOSITE MATERIALS AND STRUCTURES L T P C
3 0 0 3

OBJECTIVE

To understand the fabrication, analysis and design of composite materials & structures.

UNIT I INTRODUCTION 10

Classification and characteristics of composite materials - Types of fiber and resin materials, functions and their properties – Application of composite to aircraft structures-Micromechanics-Mechanics of materials, Elasticity approaches-Mass and volume fraction of fibers and resins-Effect of voids, Effect of temperature and moisture.

UNIT II MACROMECHANICS 10

Hooke's law for orthotropic and anisotropic materials-Lamina stress-strain relations referred to natural axes and arbitrary axes.

UNIT III ANALYSIS OF LAMINATED COMPOSITES 10

Governing equations for anisotropic and orthotropic plates- Angle-ply and cross ply laminates- Analysis for simpler cases of composite plates and beams - Interlaminar stresses.

UNIT IV MANUFACTURING & FABRICATION PROCESSES 8

Manufacture of glass, boron and carbon fibers-Manufacture of FRP components- Open mould and closed mould processes. Properties and functions of resins.

UNIT V OTHER METHODS OF ANALYSIS AND FAILURE THEORY 7

Netting analysis- Failure criteria-Flexural rigidity of Sandwich beams and plates.

L : 45 – TOTAL NUMBER OF PERIODS : 45

TEXT BOOKS

1. R.M. Jones, "Mechanics of Composite Materials", 2nd Edition, Taylor & Francis, 1999
2. L.R. Calcote, "Analysis of laminated structures", Van Nostrand Reinhold Co., 1989.
3 Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997

REFERENCES

1. G.Lubin, "Hand Book on Fibre glass and advanced plastic composites", Van Nostrand Co., New York, 1989.
2. B.D. Agarwal and L.J. Broutman, "Analysis and Performance of fiber composites", John-Wiley and Sons, 1990.