ANNA UNIVERSITY - COIMBATORE – 13

CURRICULUM - 2007

POST GRADUATE PROGRAMME

Branch: M.E. (AERONAUTICAL ENGINEERING)

SEMESTER – I (FULL- TIME)

Subject Code	Subject Name	L	T	P	M
THEORY					
07AE101	Applied Mathematics - I	3	1	0	100
07AE102	Aerodynamics - I	3	1	0	100
07AE103	Aerospace Propulsion	3	1	0	100
07AE104	Aircraft Structures	3	1	0	100
07AEExx	Elective – I	3	0	0	100
07AEExx	Elective – II	3	0	0	100
	TOTAL	**18**	**4**	**0**	**600**

SEMESTER – II (FULL- TIME)

Subject Code	Subject Name	L	T	P	M
THEORY					
07AE201	Aerodynamics - II	3	1	0	100
07AE202	Composite Materials and Structures	3	0	0	100
07AE203	Computational Fluid Dynamics	3	2	0	100
07AE204	Rocketry and Space Mechanics	3	0	0	100
07AE205	Theory of Vibrations	3	0	0	100
07AE206	Finite Element Methods	3	1	0	100
	TOTAL	**18**	**4**	**0**	**600**

SEMESTER – III (FULL- TIME)

Subject Code	Subject Name	L	T	P	M
THEORY					
07AEExx	Elective – III	3	0	0	100
07AEExx	Elective – IV	3	0	0	100
07AEExx	Elective – V	3	0	0	100
PRACTICAL					
07AE301	Aerodynamics Laboratory	0	0	4	100
07AE302	Structures Laboratory	0	0	4	100
07AE303	Project Work – Phase I	0	0	12	200
	TOTAL	**9**	**0**	**20**	**700**

SEMESTER – IV (FULL- TIME)

Subject Code	Subject Name	L	T	P	M
PRACTICAL					
07AE401	Project Work – Phase II	0	0	24	400
	TOTAL	**0**	**0**	**24**	**400**

LIST OF ELECTIVES

Subject Code	Subject Name	L	T	P	M
THEORY					
07AEE01	Experimental Stress Analysis	3	0	0	100
07AEE02	Theory of Elasticity	3	0	0	100
07AEE03	Advanced Propulsion Systems	3	0	0	100
07AEE04	Aero Elasticity	3	0	0	100
07AEE05	Aircraft Design	3	0	0	100
07AEE06	Applied Mathematics - II	3	0	0	100
07AEE07	Boundary Layer Theory	3	0	0	100
07AEE08	Computer Methods in Engineering	2	2	0	100
07AEE09	Cryogenics	3	0	0	100
07AEE10	Fatigue and Fracture Mechanics	3	0	0	100
07AEE11	Heat Transfer	3	0	0	100
07AEE12	Helicopter Aerodynamics	3	0	0	100
07AEE13	High Temperature Gas Dynamics	3	0	0	100
07AEE14	High Temperature Problems in Structures	3	0	0	100
07AEE15	Hypersonic Aerodynamics	3	0	0	100
07AEE16	Industrial Aerodynamics	3	0	0	100
07AEE17	Non-Linear Vibrations	3	0	0	100
07AEE18	Structural Dynamics	3	0	0	100
07AEE19	Theory of Plates and Shells	3	0	0	100

SEMESTER - I

07AE101 APPLIED MATHEMATICS - I

L	T	P	M
3	1	0	100

UNIT - I NON-LINEAR ORDINARY DIFFERENTIAL EQUATIONS (12)

Equations reducible to linear form - Bernoulli's equation - Solvable for x or y or p types - Riccatti's equation and its special forms - The nonlinear pendulum - Elliptic integral - perturbation solution

UNIT - II INTERPOLATION AND NUMERICAL INTEGRATION (12)

Lagrange's Interpolation - Hermite interpolation - Cubic spline interpolation - Gaussian Quadrature - Newton Cotes integration formulae - Robmerg's integration - Double Integration

UNIT - III MATRIX THEORY (12)

Special vectors and matrices - Augmented matrix inversion - Least square normal equations - Choleskey Decomposition - Inverse using decomposition - Inverse using partitioning - Singular value decomposition

UNIT - IV NUMERICAL TECHNIQUES (12)

Solution of Ordinary differential equations - Shooting method, Runge-Kutta method of order 4, Milne's predictor-corrector method - Adam-Bashforth method - Solution of BVPs by difference methods - Stability of the classical as well as Crank-Nicolson schemes for . - Convergence of solution

UNIT - V CALCULUS OF VARATIONS (12)

Euler's equation - Several independent variables - Integrals involving derivatives higher than the first - Problems with constraints - Ritz method

Reference Books **Lecture 45 Tutorial 15 Total 60**

1 S. Balachandra Rao and H.R. Anuradha, "Differential equation with applications and programs, University Press (India) Ltd., 1996

2 K. Sankara Rao, "Numerical Methods for Scientists and Engineers", Prentice-Hall of India Private Limited, New Delhi, 2001

3 M.K. Jain, S.R.K. Iyengar and R.K. Jain, "Numerical methods for scientific and engineering computation", Wiley Eastern Limited, 1987

4 Elsgolc, L.E., "Calculus of Variation", Pergamon Press, Addison-Wesley Publishing Company Inc., 1961

5 Marple, S.L., "Digital spectral analysis", Prentice Hall(N.J.), 1987

6 Stephenson, G., Radmore, P.M., "Advanced mathematical methods for scientific and engineering science students", Cambridge University Press, 1990

7 Wilfred Kaplan, "Advanced Mathematics for Engineers", Addison-Wesley Publishing Co., 1981

8 Froberg, C.E., "Numerical Mathematics", The Benjamin/Cummings Publishing Co., Inc., 1985.

9 S.S. Sastry, "Introductory methods of Numerical Analysis", Prentice Hall of India (Pvt.) Ltd., New Delhi, 3rd edition, 1998.

10 Frank Jr. Ayres, "Matrices", Schaum's Outline Series, Mcgraw-Hill Publisher

07AE102 AERODYNAMICS - I

L	T	P	M
3	1	0	100

UNIT - I REVIEW OF BASIC FLUID MECHANICS (11)

Continuity and Momentum equations, Point source and sink, 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 SUBSONIC AIRFOIL THEORY (13)

Conformal Transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications.

UNIT - III SUBSONIC WING THEORY (11)

Vortex line, Horse shoe vortex, Biot and savart law, lifting line theory, effects of aspect Ratio, planform and taper ratio.

UNIT - IV COMPRESSIBLE FLOW THEORY (12)

Isentropic flows – shock and expansion waves, compressibility effects on aerodynamic Coefficients, method of characteristics – small perturbation theory.

UNIT - V VISCOUS FLOW AND FLOW MEASUREMENTS (13)

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 – Measurements in wind tunnels.

Reference Books **Lecture 45 Tutorial 15 Total 60**

1 J.D. Anderson, “Fundamental of Aerodynamics”, McGraw-Hill Book Co., New York, 1985.

2 Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 1995.

3 Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press, 1982.

4 E.L. Houghton and N.B. Caruthers, Aerodynamics for Engineering Students, Edward Arnold Publishers Ltd., London (First Indian Edition), 1988

5 Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York, 1989.

6 W.H. Rae and A. Pope, “Low speed Wind Tunnel Testing”, John Wiley Publications, 1984.

07AE103 AEROSPACE PROPULSION

L	T	P	M
3	1	0	100

UNIT - I ELEMENTS OF AIRCRAFT PROPULSION (13)

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 – Methods of Thrust augmentation.

UNIT - II INLETS AND COMBUSTION CHAMBERS (8)

Subsonic and supersonic inlets – Relation between minimum area ratio and external deceleration ratio – Starting problem in supersonic inlets –Modes of inlet operation. Classification of Combustion chambers - Combustion chamber performance – Flame tube cooling – Flame stabilization.

UNIT - III COMPRESSORS AND TURBINES (19)

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

UNIT - IV RAM JET, SCRAM JET PROPULSION AND NOZZLES (8)

Principle of ramjets, Scramjet- problems relating to supersonic combustion-Integral ram rocket-sample Ramjet design calculations - jet nozzle – Efficiencies – Over expanded, under and optimum expansion in nozzles – Thrust reversal.

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.

Reference Books **Lecture 45 Tutorial 15 Total 60**

1 Hill,P.G. and Peterson, C.R. Mechanics and Thermodynamics of Propulsion, Addission – Wesley Longman Inc. 1999

2 Cohen, H. Rogers, G.F.C. and Saravanamuttoo,H.I.H, Gas Turbine Theory, Longman,1989

3 G.C. Oates, “Aerothermodynamics of Aircraft Engine Components”, AIAA Education Series, 1985.

4 G.P.Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 5th Edition, 1986.

5 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.

07AE104 AIRCRAFT STRUCTURES

L	T	P	M
3	1	0	100

UNIT - I BENDING OF BEAMS (13)

Stresses in beams of symmetrical and unsymmetrical sections -Box beams – General formula for bending stresses- principal axes method – Neutral axis method.

UNIT - II MONOCOQUE AND SEMI MONOCOQUE STRUCTURE (13)

Shear stress – Shear flow – Shear centre – Torsion and flexure of thin walled box type of structures – Flexural axis and axis of twist in open and closed sections.

UNIT - III STIFFENED STRUCTURES (13)

Shear flow in open and closed section with stiffeners - Analysis of rings and frames – Torsional shear flow in single and multi cell tubes – Torsional and flexural shear flow in multi cell tubes.

UNIT - IV STABILITY PROBLEMS (13)

Stability problems of thin walled structures – Flexural, torsional and local failures – Influence of eccentricity and in elasticity – Buckling of plates and sheet stringer combinations - crippling loads – Tension field theory.

UNIT - V ANALYSIS OF AIRCRAFT STRUCTUREAL COMPONENTS (8)

Shear and bending moment distribution of wing and fuselage – Shear resistant web – Tension field web beams

Reference Books **Lecture 45 Tutorial 15 Total 60**

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.

3 Peery, D.J. and Azar, J.J., Aircraft Structures, 2nd Edition, McGraw-Hill, New York, 1993.

4 Stephen P. Tinnoshenko & S.woinowsky Krieger, Theory of Plates and Shells, 2nd Edition, McGraw-Hill, Singapore, 1990.

5 Rivello, R.M., Theory and Analysis of Flight structures, McGraw-Hill, N.Y., 1993

SEMESTER - II

07AE201 AERODYNAMICS II

L	T	P	M
3	1	0	100

UNIT - I PRINCIPLES OF FLIGHT (8)

Physical properties and structure of the atmosphere, Temperature, pressure and altitude Relationship, Measurement of speed – True and Indicated Air speed, Components of an Airplane and their functions, Different types of flight vehicles.

UNIT - II DRAG OF AIRPLANE (9)

Types of Drag - effects of Reynold'd number - Streamlined and bluff bodies - Momentum theory of finite wings - Drag polar - Drag reduction of airplanes.

UNIT - III AIRCRAFT PERFORMANCE (16)

Steady level flight conditions for minimum drag and minimum power required, Gliding and Climbing flight, Range and endurance, Take-off and landing, High left devices, Thrust Augmentation, Turning performance, V-n diagram.

UNIT - IV PROPELLER THEORY (7)

Froude momentum and blade element theory of propellers - Fixed and Variable pitch propellers – Propeller coefficients – Propeller chart

UNIT - V AIRCRAFT STABILITY AND CONTROL (20)

Degrees of freedom of a system, statie and dynamic stability, static longitudinal stability, Static lateral stability, static directional stability, dynamic longitudinal stability, dynamic lateral And directional stability.

Reference Books **Lecture 45 Tutorial 15 Total 60**

1 Houghton, E.L., and Caruthers, N.B., Aerodynamics for engineering students, Edward Arnold Publishers, 1988.

2 Perkins C.D., & Hage, R.E. Airplane performance, stability and control, Wiley Toppan, 1974.

3 Kuethe, A.M., and Chow, C.Y., Foundations of Aerodynamics, John Wiley & Sons, 1982.

4 Clancey,L.J. Aerodynamics, Pitman, 1986.

5 Babister, A.W. Aircraft stability and response, Pergamon Press, 1980.

6 Nelson, R.C. Flight Stability & Automatic Control, McGraw-Hill, 1989.

7 McCormic, B.W., Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.

07AE202	COMPOSITE MATERIALS AND STRUCTURE	L	T	P	M
		3	0	0	100

UNIT - I CLASSIFICATION AND CHARACTERISTIC OF COMPOSITE MATERIALS (3)

Need for the composite materials - Types of fiber and resin materials and their properties – Types of composites - Application of composite to aircraft structures

UNIT - II BASIC CONCEPTS (12)

Hooke's law for orthotropic and anisotropic materials. Micromechanics and macro mechanics. Lamina stress-strain relations referred and principal material directions and arbitrary axes.

UNIT - III ANALYSIS OF LAMINATED COMPOSITES (17)

Governing equations for anisotropic and orthotropic plates. Angle-ply and cross ply laminates. Static, dynamic and stability analysis for simpler cases of composite plates. Interlaminar stresses.

UNIT - IV OTHER METHODS OF ANALYSIS AND FAILURE THEORY (8)

Netting analysis, Failure criteria. Sandwich construction.

UNIT - V MANUFACTURING & FABRICATION PROCESSES (5)

Manufacturing of glass, boron and carbon fibres. Open mould and closed mould processes.

Reference Books **Total 45**

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 G.Lubin, "Hand Book on Fibre glass and advanced plastic composites", Van Nostrand Co., New York, 1989.

4 B.D. Agarwal and L.J. Broutman, "Analysis and Performance of fiber composites", John-Wiley and Sons, 1990.

5 Autar K. Kaw, Mechanics of Composite Materials, CRC Press LLC, 1997

07AE203 COMPUTATIONAL FLUID DYNAMICS

L	T	P	M
3	2	0	100

UNIT - I NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS (20)

Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, Stability analysis of linear system. Finding solution of a simple gas dynamic problem, Local similar solutions of boundary layer equations, Numerical integration and shooting technique.

UNIT - II TRANSONIC RELAXATION TECHNIQUES (10)

Small perturbation flows, Transonic small perturbation (TSP) equations, Central and backward difference schemes, conservation equations and shockpoint operator, Line relaxation techniques, Acceleration of convergence rate, Jameson's rotated difference scheme stretching of coordinates, shock fitting techniques Flow in body fitted coordinate system.

UNIT - III TIME DEPENDENT METHODS (14)

Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Some time dependent solutions of gas dynamic problems.

UNIT - IV PANEL METHOD (15)

Elements of two and three dimensional panels, panel singularities. Application of panel method to incompressible, compressible, subsonic and supersonic flows.

UNIT - V GRID GENERATION (16)

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation.

Reference Books **Lecture 45 Tutorial 30 Total 75**

1 T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002

2 C.Y.Chow, "Introduction to computational fluid dynamics", John Wiley, 1979.

3 A.A. Hirsch, 'Introduction to computational fluid dynamics", McGraw-Hill, 1989.

4 T.K.Bose, "Computation Fluid Dynamics" Wiley Eastern Ltd., 1988.

5 H.J. Wirz and J.J. Smeldern "Numerical methods in fluid dynamics", McGraw-Hill & Co., 1978.

07AE204 ROCKETRY AND SPACE MECHANICS

L	T	P	M
3	0	0	100

UNIT - I ORBITAL MECHANICS (10)

Description of solar system – Keplers Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobis 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 (11)

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 (10)

Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, foron 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 MATERIALS FOR SPACECRAFT AND MISSILES (5)

Selections of materials for spacecraft and missiles – special requirements of materials to perform under adverse conditions – ablative materials.

Reference Books **Total 45**

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.

3 Van de Kamp, "Elements of astromechanics", Pitman Publishing Co., Ltd., London, 1980.

4 E.R. Parker, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982.

07AE205 THEORY OF VIBRATIONS

L	T	P	M
3	0	0	100

UNIT - I INTRODUCTION (8)

Simple harmonic motion, definition of terminologies, Review of Newton's, Laws, D'Alembert's principle, Energy methods.

UNIT - II SINGLE DEGREE OF FREEDOM SYSTEMS (8)

Free vibrations free damped vibrations, forced excitations with and without damping, support excitation, vibration measuring instruments.

UNIT - III MULTI-DEGREES OF FREEDOM SYSTEMS (12)

Two degrees of freedom systems, Static and dynamic couplings, vibration absorber, Principle coordinates, Principal modes, orthogonality conditions. Hamilton's Prinicple, Lagrangean equation and applications.

UNIT - IV VIBRATION OF ELASTIC BODIES (12)

Longitudinal vibration - String or stretched cord - Lateral vibration - Torsional vibration. Approximate methods for calculating natural frequencies.

UNIT - V ELEMENTS OF AEROELASTICITY (5)

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

Reference Books **Total 45**

1 Timoshenko, S. Vibration Problems in Engineering, John Wiley & Sons, Inc., 1987.

2 Meirovitch, L. Elements of Vibration Analysis, McGraw-Hill Inc., 1986.

3 Fung, Y.C., An Introduction to the Theory of Aeroelasticity, John Wiley & Sons Inc., New York, 1985.

4 F.S. Tse., I.F. Morse and R.T. Hinkle, Mechanical Vibrations, Prentice-Hall of India, 1985.

5 Rao.J.S. and Gupta.K. Theory and Practice of Mechanical Vibrations Wiley Eastern Ltd., New Dehli, 1999

07AE206	FINITE ELEMENT METHODS	L	T	P	M
		3	1	0	100

UNIT - I INTRODUCTION (11)

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods - Stiffness and flexibility matrices for simple cases - Basic concepts of finite element method - Formulation of governing equations and convergence criteria.

UNIT - II DISCRETE ELEMENTS (16)

Use of bar and beam elements in structural analysis – Bar of varying section – Termperature effects

UNIT - III CONTINUUM ELEMENTS (20)

Different forms of 2-D elements and their applications for plane stress, plane strain and axisymmetric problems – CST Element – LST Element - Consistent and lumped formulation. Use of local co-ordinates. Numerical integration. – Application to heat transfer problems

UNIT - IV ISOPARAMETRIC ELEMENTS (9)

Definition and use of different forms of 2-D and 3-D elements. - Formulation of element stiffness matrix – Load vector

UNIT - V SOLUTION SCHEMES (4)

Different methods of solution of simultaneous equations governing static, dynamics and stability problems. General purpose Software packages.

Reference Books **Lecture 45 Tutorial 15 Total 60**

1 Segerlind,L.J. “Applied Finite Element Analysis”, Second Edition, John Wiley and Sons Inc., New York, 1984.

2 Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Printice Hall, 2002

3 K.J. Bathe and E.L. Wilson, “Numerical Methods in Finite Elements Analysis”, Prentice Hall of India Ltd., 1983.

4 Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt “Concepts and Applications of Finite Element Analysis”, 4th Edition, John Wiley & Sons, 2002.

5 C.S. Krishnamurthy, “Finite Elements Analysis”, Tata McGraw-Hill, 1987.

SEMESTER - III

PRACTICALS

07AE301 AERODYNAMICS LABORATORY 0 0 3 100

LIST OF EXPERIMENTS

1 Calibration of subsonic wind tunnel

2 Pressure distribution over a smooth and rough cylinders

3 Pressure distribution over a two dimensional symmetric aerofoil

4 Pressure distribution over a two dimensional cambered aerofoil

5 Force measurement using wind tunnel balance for various models

6 Pressure distribution over a three dimensional symmetric aerofoil

7 Pressure distribution over a three dimensional cambered aerofoil

8 Flow visualization studies in incompressible flows

9 Calibration of supersonic wind tunnel

10 Supersonic flow visualization studies

Total 45

Sl. No.	Name of the Equipment	Quantity	Expt. No.
1	Wind Tunnel test section size around 300 X 300 mm with test section flow speed of 70 m/s	1	1 – 7
2	2 - D airfoil sections symmetrical & Cambered	2 (each)	3 & 4
3	3 - D airfoil sections symmetrical & Cambered	2 (each)	6 & 7
4	Angle of incidence changing mechanism	1	3 – 7
5	Multiple manometer stand with 20 -30 tubes	1	1 – 7
6	U- tube manometer	1	1 – 7
7	Velocity survey rake	1	1
8	Total pressure probes	4	1
9	Pitot-Static tubes	4	1 – 7
10	Rough and smooth circular cylindrical models	1 (each)	2
11	Wind Tunnel balances (3 or 5 or 6 components)	1	5
12	Pressure transducers with digital display	1 set	1 – 10
13	Hele-Shaw apparatus, smoke tunnel, water flow channel	1	8
14	Supersonic wind tunnel with test section size 100 X100 mm with storage tank capacity of 500 cubic ft at 20 bar	1	9, 10
15	Wooden models of cone, wedge and blunt body configurations of suitable size for flow visualization in supersonic tunnels	1	10
16	Shadow graph or Schlieren system	1	10

PRACTICALS

07AE302 STRUCTURES LABORATORY 0 0 3 100

LIST OF EXPERIMENTS

1. Maxwell Reciprocal Theorem and Principle of Superposition
2. Unsymmetrical Bending of Beams
3. Shear Centre Location for Open Section
4. Shear Centre Location for Closed Section
5. Flexibility Matrix for Cantilever Beam
6. Beam with Combined Loading
7. Calibration of Photo Elastic Materials
8. Stresses in Circular Disc Under Diametrical Compression – Photo Elastic Method
9. Stresses in Beams using Photo Elastic Method
10. Vibration of Beams with Different Support Conditions

Total 45

Sl. No.	Name of the Equipment	Quantity	Expt. No.
1	Beam Test Setup with various End Conditions	2	1,2,3,4
2	Dial Gauges	12	1,2,3,4
3	Weight 1 Kg	10	1,2,3,4
4	Weight 2Kg	10	1,2,3,4
5	Weight pans	6	1
6	Unsymmetrical sections like “Z” , angle	2 (each)	2,3
7	Square section, Circular section etc.	2 (each)	4
8	Strain indicator & Strain gauges	1&20	5,6
9	Photo Elastic Test bench with loading	1 set	7,8,9
10	Amplifier	2	10
11	Exciter	2	10
12	Pickup	2	10
13	Oscilloscope	2	10

LIST OF ELECTIVES

07AEE01 EXPERIMENTAL STRESS ANALYSIS

L	T	P	M
3	0	0	100

UNIT - I INTRODUCTION (8)

Extensometers – Types – Mechanical, Electrical, Electronic and Optical – Review of bridge circuits.

UNIT - II STRAIN GAUGE TECHNIQUES (12)

Strain gauge and transducers for measurement of static and dynamic loads – Instrumentation, measurement and recording systems.

UNIT - III PHOTO ELASTIC TECHNIQUES (10)

Stress analysis by two and three dimensional photo elasticity – Interpretation of stress patterns – Typical applications – Description and uses of reflection polariscope.

UNIT - IV INTERFERAMETRY TECHNIQUES (5)

Moire fringes – Laser holography – Grid methods

UNIT - V NON DESTRUCTIVE TECHNIQUES (10)

Stress analysis by stress coat –Induction heating instrumentation, measurement and recording techniques – Creep testing. X-ray, Ultrasonic, Acoustic emission – applications.

Reference Books **Total 45**

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, TMH, New delhi, 1984

3 P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.

4 M. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.

5 G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.

6 A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

07AEE02	THEORY OF ELASTICITY	L	T	P	M
		3	0	0	100

UNIT - I INTRODUCTION (8)

Definition, notations and sign conventions for stress and strain – Stress - strain law – Number of elastic constants – Stress ellipsoid – stress invariants – Principal stresses in 2-D and 3-D

UNIT - II BASIC EQUATIONS OF ELASTICITY (8)

Equations of equilibrium – Compatibility equations in strains and stresses – Boundary Conditions - Saint-Venant's principle.

UNIT - III 2 - D PROBLEMS IN CARTISIAN COORDINATES (12)

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 – Axi symmetric problems - Kirsch, Boussinasque's and Michell's problems.

UNIT - V SAINT VENANT'S TORSION (5)

Saint Venant's Semi-Inverse method. Torsion of elliptical, equilateral triangular and rectangular sections.

Reference Books **Total 45**

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.

3 Ugural, A.C and Fenster, S.K, Advanced Strength and Applied Elasticity, Prentice hall, 2003

4 Wang, C.T. Applied elasticity, McGraw Hill 1993

5 Enrico Volterra and Caines, J.H, Advanced strength of Materials, Prentice Hall, 1991

07AEE03 ADVANCED PROPULSION SYSTEMS

L	T	P	M
3	0	0	100

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.

Reference Books **Total 45**

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

2 Hypersonic Aerothermodynamics by John T. Bertin, 1994 published by AIAA Inc., Washington D.C.

3 Modern Compressible Flow with Historical perspective John. D.Anderson, Jr. McGraw-Hill Series, New York, 1996.

4 Hypersonic Airbreathing propulsion by William H. Heiser and David T. Pratt, AIAA Education Series.

07AEE04 AEROELASTICITY

L	T	P	M
3	0	0	100

UNIT - I AEROELASTIC PHENOMENA (6)

Stability versus response problems – The aero-elastic triangle of forces – Aeroplasticity in Aircraft Design – Prevention of aeroelastic instabilities.

UNIT - II DIVERGENCE OF A LIFTING SURFACE (10)

Simple two dimensional idealisations-Strip theory – Freedom 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 – Semirigid theory and successive approximations – Lift distribution – Rigid and elastic wings.

UNIT - IV FLUTTER PHENOMENON (14)

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

UNIT - V EXAMPLES OF AEROELASTIC PROBLEMS IN CIVIL AND MECHANICAL ENGINEERING (6)

Galloping of transmission lines and flow induced vibrations of tall slender structures and suspension bridges.

Reference Books **Total 45**

1 E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986.

2 Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons Inc., New York, 1990.

3 R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1987.

4 R.H. Scanlan and R.Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.

07AEE05 AIRCRAFT DESIGN

L	T	P	M
3	0	0	100

UNIT - I REVIEW OF DEVELOPMENTS IN AVIATION (9)

Categories and types of aircraft specifications – 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 (9)

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

UNIT - III PRELIMINARY DESIGN (9)

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 (9)

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 (9)

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.

Reference Books **Total 45**

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

07AEE06 APPLIED MATHEMATICS – II

L	T	P	M
3	0	0	100

UNIT - I SPECIAL FUNCTIONS (9)

Hermite, Lagurre, Chebyshev Polynomials – their properties.

UNIT - II INTEGRAL EQUATIONS-I (9)

Relation between linear differential and integral equations – Green's function and its use in reducing boundary value problems to integral equations. Fredholm equations.

UNIT - III INTEGRAL EQUATIONS – II (9)

Hilbert – Schmidt theory – altercative methods for the solution of integral equations of the second kind. The Ncumann series. Orthogonal kernals.

UNIT - IV TENSOR ANALYSIS – I (9)

Introduction – The summation convention – Contravariant vectors, Covariant vectors – Higher order tensors. Basic properties – Quotient law. Symmetric and skew symmetric tensors. The metric tensor. Conjugate reciprocal tensor and associated tensors.

UNIT - V TENSOR ANALYSIS – II (9)

Derivatives of the fundamental tensor. Transformation of Christoffel symbols. Covariant derivatives and curl of a covariant vector - Contravariant vector. Riemann Christoffel tensor. The Ricci tensor - The curvature tensor.

Reference Books **Total 45**

1 Venkataraman, M.K., "Higher Mathematics for Engineering and Science", The National publishing Co., Madras, 1991.

2 F.B. Hildebrand, 'Methods of applied Mathematics", Prentice Hall, New Delhi, 1985.

3 M.R. Spiegel, "Theory and Problems of vector analysis and an introduction to Tensor Analysis", Schaum Series, McGraw-Hill, 1985.

4 Kanwal, R.P.Linear Integral Equations – Theory and technique,Academic Press, Newyark, 1971

5 Sharama, J.N. and Gupta,R.K, Special Functions, Krishna Prakashan Mandir1991

07AEE07 BOUNDARY LAYER THEORY

L	T	P	M
3	0	0	100

UNIT - I CONCEPTS IN IDEAL FLUID FLOW (10)

Basic laws of fluid flow – continuity, momentum and energy equations as applied to system and control volume – concepts of flow fields – flow around bodies – moment of momentum theorem and its application to fixed and moving vanes – Hot wire and laser Doppler anemometry.

UNIT - II INTRODUCTION TO BOUNDARY LAYER (10)

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

UNIT - III LAMINAR AND TURBULENT BOUNDARY LAYERS (5)

Laminar and turbulent flows on a flat plate – Laminar and turbulent boundary layers – Transition from laminar to turbulent boundary layers.

UNIT - IV APPROXIMATE SOLUTION TO BOUNDARY LAYER EQUATIONS (14)

Momentum Integral Equation for boundary layer flow – Introduction to axisymmetric and three dimensional boundary layer equations – von Karman – Polhausen method.

UNIT - V HEAT TRANSFER IN BOUNDARY LAYER (6)

Introduction to heat transfer in boundary layers – Thermal boundary layer – Turbulent boundary layer on a flat plate – flows in pressure gradient – boundary layer control.

Reference Books **Total 45**

1 H. Schlichting, “Boundary Layer Theory”, McGraw-Hill, New York, 1979.
2 Frank White – Viscous Fluid flow – McGraw Hill, 1998
3 A.J. Reynolds, “Turbulent flows in Engineering”, John Wiley & Sons, 1980.
4 Ronald L., Panton, “Incompressible fluid flow”, John Wiley & Sons, 1984.
5 Tuncer Cebeci and Peter Bradshaw, “Momentum transfer in boundary layers”, Hemisphere Publishing Corporation, 1977.

07AEE08	COMPUTER METHODS IN ENGINEERING	L	T	P	M
		2	2	0	100

UNIT - I PROGRAMMING (12)

Review of basic syntax of language C

UNIT - II SIMULTANEOUS ALGEBRAIC EQUATIONS (12)

Review of various methods of solution (Elimination, iterative and factorisation methods) Methods of solution to eigen value problems. Computer exercise.

UNIT - III LINEAR AND NON-LINEAR DIFFERENTIAL EQUATIONS (12)

Euler's and Runge-Kutta method. Case study.

UNIT - IV INTRODUCTION TO CFD (12)

Basic fluid dynamic equations – Stability analysis of linear system – Elements of panel methods.

UNIT - V STANDARD PROGRAMMING PACKAGES & APPLICATION ORIENTED PROBLEM SOLVING (12)

Exercise in numerical networks using Borland C++ and Turbo C.

Reference Books **Lecture 30 Tutorial 30 Total 60**

1 Byron S.Gottfired, Theory and Problems – Programming in C, Schaum,s series, Tata McGraw Hill Edition, 1994

2 S. Rajasekaran, "Numerical Methods in Engineering, A.H.Wheelar & Co., 1986.

3 K.J. Bathe & E.L. Wilson, "Numerical Methods in Finite Element Analysis", Prentice Hall of India Ltd., 1983.

4 T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002

5 M.K. Venkataraman, "Higher Mathematics for Engineering and Science" The Material Publishing Co., Madras, 1981.

6 E.Kreyszig, "Advanced Engineering Mathematics", Wiley Eastern Ltd., 1982.

7 A.H. Nayfeh and D.T.Mook, "Non-linear Oscillations", John Wiley, New York, 1989.

07AEE09 CRYOGENICS

L	T	P	M
3	0	0	100

UNIT - I FUNDAMENTALS OF CRYOGENICS (10)

Theory behind the production of low temperature – expansion engine – heat exchangers – Cascade process - Joule Thomson and Magnetic effects – cryogenic liquids as cryogenic propellants for cryogenic rocket engines – properties of various cryogenic propellants – handling problems associated with cryogenic propellants.

UNIT - II CRYOGENIC SYSTEMS EFFICIENCY (6)

Types of losses and efficiency of cycles – amount of cooling – the features liquefied – cooling coefficient of performance – Thermodynamic efficiency – The energy balancing method.

UNIT - III THERMODYNAMIC CYCLES FOR CRYOGENIC PLANTS (10)

Classification of cryogenic cycles – The Structure of cycles – Throttle expansion cycles – Expander cycles – Mixed throttle expansion and expander cycles – Thermodynamic analysis – Numerical problems.

UNIT - IV PECULIAR PROBLEMS ASSOCIATED WITH CRYOPROPELLANTS (12)

Storage problems of cryogenic propellants – cryogenic loading Aerospace Materials – zero gravity problems associated with cryopropellants – phenomenon of tank collapse – geysering effect.

UNIT - V CRYOGENIC ROCKET ENGINES (7)

Peculiar design difficulties associated with the design of feed system, injector and thrust chamber of cryogenic rocket engines – Relative performan ce of cryogenic when compared to non-cryo engines.

Reference Books **Total 45**

1 Haseldom, G., Cryogenic Fundamentals, Academic Press, 1971.
2 Hazel D.K. & Hungdh, “Design of Liquid Propellant Rocket Engines”, N.A.S.A. Special Publications – 125, 1971.
3 Sutton, G.P. “Rocket Propulsion Elements”, John Wiley, 1993.
4 Barron, R.F., Cryogenic Systems, Oxford University, 1985.
5 Parner, S.F., Propellant Chemistry Reinfold Publishing Corporation, New York, 1985.

07AEE10 FATIGUE AND FRACTURE MECHANICS

L	T	P	M
3	0	0	100

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.

Reference Books **Total 45**

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.

3 W.Barrois and L.Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983.

4 C.G.Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

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07AEE11 HEAT TRANSFER

L	T	P	M
3	0	0	100

UNIT - I BASICS OF HEAT TRANSFER (6)

Significance of heat transfer analysis – Different modes of heat transfer – Dimensional Analysis and non dimensional numbers

UNIT - II CONDUCTIVE HEAT TRANSFER (15)

Conduction – Convection systems – Mathematical analysis of 1-D and 2-D heat conduction – Problems in cartesian and polar coordinate systems – Extended surfaces – 1-D Transient analysis - Numerical solutions to steady state and transient,1D and 2- D heat conduction problems.

UNIT - III CONVECTIVE HEAT TRANSFER (12)

Governing Equations – Thermal and hydrodynamic boundary layers – Forced Convection - Heat transfer involving laminar and turbulent flows over a flat plate and through a tube – Use of various empirical relationships.

UNIT - IV RADIATIVE HEAT TRANSFER (6)

Physical mechanism of radiation – radiation shape factors – relations between shape factors – heat exchange between non-black bodies – radiation shields – solar radiation – radiation heat transfer coefficient.

UNIT - V HEAT EXCHANGERS (6)

Types of heat exchangers – Methods of analysis – LMTD and NTU.

Reference Books **Total 45**

1 Yunus A. Cengel, Heat Transfer – A Practical Approach Tata McGraw Hill Edition, 2003

2 S.C. Sachdeva, “Fundamentals of Engineering Heat & Mass Transfer”, Wiley Eastern Ltd., New Delhi, 1981.

3 John H. Lienhard, “A Heat Transfer Text Book”, Prentice Hall Inc., 1981.

4 J.P. Holman, “Heat Transfer”, McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.

07AEE12 HELICOPTER AERODYNAMICS

L	T	P	M
3	0	0	100

UNIT - I LIFT, PROPULSION AND CONTROL OF V/STOL AIRCRAFT (10)

Various configurations – propeller, rotor, ducted fan and jet lift-Tilt wing and vectored thrust – performance of VTOL and STOL aircraft in hover, transition and forward motion.

UNIT - II ELEMENTS OF HELICOPTER AERODYNAMICS (8)

Configurations based on torque reaction – Jet rotors and compound helicopters – Methods of control – collective and cyclic pitches changes – Lead – lag and flapping hinges.

UNIT - III IDEAL ROTOR THEORY (9)

Hovering performance – Momentum and simple blade element theories – Figure of merit – Profile and induced power estimation – Constant chord and ideal twist rotors

UNIT - IV POWER ESTIMATES (9)

Induced, profile and parasite power requirements in forward flight – performance curves with effects of altitude – Preliminary ideas on helicopter stability.

UNIT - V GROUND EFFECT MACHINES (9)

Types – Hover height, lift augmentation and power calculations for plenum chamber and peripheral jet machines – Drag of hovercraft on land and water. Applications of hovercraft

Reference Books **Total 45**

1. A. Gessow and G.C.Meyers, “Aerodynamics of the Helicopter”, Macmillan and Co., New York, 1982.
2. G.H. Elsley and A.J. Devereux, “Hovercraft Design and Construction, David Charies, London, 1982.
3. B.W. McCormic, “Aerodynamics of V/STOL Flight”, Academic Press, New York, 1978.
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07AEE13 HIGH TEMPERATURE GAS DYNAMICS

L	T	P	M
3	0	0	100

UNIT - I INTRODUCTION (7)

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.

UNIT - II STATISTICAL THERMODYNAMICS (7)

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 chemical and vibrational non equilibrium.

UNIT - IV INVISCID HIGH TEMPERATURE FLOWS (12)

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.

Reference Books **Total 45**

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

2 Modern Compressible Flow with Historical perspective John D. Anderson, Jr. McGraw-Hill Series, New York, 1996.

3 Hypersonic Air breathing propulsion by William H. Heiser and David T. Pratt, AIAA Education Series.

4 Hypersonic Aerothermodynamics by John T. Bertin, 1994 published by AIAA Inc., Washington, D.C.

07AEE14	HIGH TEMPERATURE PROBLEMS IN STRUCTURES	L	T	P	M
		3	0	0	100

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 – Adibatic 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.

Reference Books **Total 45**

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.

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

07AEE15 HYPERSONIC AERODYNAMICS

L	T	P	M
3	0	0	100

UNIT - I BASICS OF HYPERSONIC AERODYNAMICS (7)

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 (7)

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 (8)

Approximate methods hypersonic small disturbance equation and theory – thin shock layer theory: exact methods of characteristics hypersonic shock wave shapes and correlations.

UNIT - IV VISCOUS HYPERSONIC FLOW THEORY (15)

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 (8)

Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

Reference Books **Total 45**

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

2 Modern Compressible Flow with Historical perspective John.D.Anderson, Jr. Hypersonic Series.

3 Hypersonic Air Breathing propulsion by William H. Heiser and David T. Praff, AIAA Education Series.

4 Hypersonic Aerothermodynamics by John T. Bertin, 1994 published by AIAA Inc., Washington D.C.

07AEE16 INDUSTRIAL AERODYNAMICS

L	T	P	M
3	0	0	100

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.

Reference Books **Total 45**

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.

3 R.D. Blevins, “Flow induced vibrations”, Van Nostrand, 1990.

4 N.G. Calvent, “Wind Power Principles”, Charles Griffin & Co., London, 1979.

07AEE17 NON-LINEAR VIBRATIONS

L	T	P	M
3	0	0	100

UNIT - I QUALITATIVE METHODS (10)

Fundamental properties of nonlinear systems. Nonlinear equations of motion of some mechanical systems Phase planes, Singular points, Liapunov stability, Subharmonic and superharmonic solutions. Bifurcation theory.

UNIT - II QUANTITATIVE METHODS (10)

Perturbation Method, Harmonic balancing, Krylov – Bogoliubov method, Method of averaging, Multiple time scales. Determination of stability criteria – characteristic exponents. Nyquists diagram. Autonomous and non- autonomous systems. Duffing's oscillator, Jump phenomena.

UNIT - III FLOW INDUCED OSCILLATIONS (10)

Self excited oscillations in mechanical systems. Van-der-Pol's oscillator, Limit cycles. Vortex induced oscillations – Strouhal number, Galloping, Mathematical model for bluff body oscillations in steady and fluctuating flows.

UNIT - IV PARAMETRIC EXCITATION (6)

Mathieu Hill equations, stability of solutions.

UNIT - V SOLUTION OF EQUATIONS (9)

Subharmonic and superharmonic solutions, multiple solutions, Poincare maps, Basin of attractions.

Reference Books **Total 45**

1 P.Hagedom, "Nonlinear Oscillations", Clarendon Press, Oxford, 1981.

2 A.H.Nayfeh and D.T.Mook, "Nonlinear Oscillations", John Wiley & Sons, New York, 1979.

3 C.Hayashi, "Nonlinear Oscillations in Physical Systems", McGraw-Hill, New York, 1984.

4 N.Minorsky, "Nonlinear Oscillations", Van Nostrand Princeton NJ, 1982.

5 R.D.Blevins, "Flow Induced Vibration", Van Nostrand, Reinhold Co., New York, 1992.

07AEE18 STRUCTURAL DYNAMICS

L	T	P	M
3	0	0	100

UNIT - I FORCE-DEFLECTION PROPERTIES OF STRUCTURES (12)

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

UNIT - II PRINCIPLES OF DYNAMICS (9)

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 relations.

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 (6)

Approximate methods of evaluating the Eigen frequencies and the dynamics response of continuous systems – Matrix methods of dynamic stress analysis.

Reference Books **Total 45**

1 F.S.Tse, I.E. Morse and H.T. Hinkle, "Mechanical Vibration", Prentice Hall of India Pvt., Ltd., New Delhi, 1988.

2 W.C. Hurty and M.F. Rubinstein, "Dynamics of Structures", Prentice Hall of India Pvt., Ltd., New Delhi, 1987.

3 R.K. Vierck, "Vibration Analysis", 2nd Edition, Thomas Y. Crowell & Co., Harper & Row Publishers, New York, U.S.A., 1989.

4 S.P. Timoshenko and D.H. Young, "Vibration Problems in Engineering", John Willey & Sons Inc., 1984.

5 Von. Karman and A.Biot, "Mathematical Methods in Engineering", McGraw-Hill Book Co., New York, 1985.

07AEE19	THEORY OF PLATES & SHELLS	L	T	P	M
		3	0	0	100

UNIT - I INTRODUCTION (3)

Plate and shell structures in aerospace vehicles.

UNIT - II SMALL DEFLECTION THEORY OF PLATES (8)

Bending of thin plates-isotropic and orthotropic flat plates of different geometry – rectangular, square and skew plates-circular plates-different edge conditions-biharmonic equation for plate deflections.

UNIT - III SHEAR DEFORMATION AND LARGE DEFLECTION THEORY OF PLATES (6)

Assumptions-shear deformation – Analysis of flat plates and applications.

UNIT - IV STABILITY OF PLATES (7)

Instability of Plates-different edge conditions – Applications.

UNIT - V SHELLS (21)

Basic concepts – Deformation – Membrance theory of shells applied to shells of form of surface of revolution. General theory of cylindrical shells – Circular cylindrical shells – spherical shells and conical shells.

Reference Books **Total 45**

1 S.P. Timoshenko and S.W.Krieger, “Theory of Plates and Shells”, II Edition McGraw-Hill, Kogakusha Ltd., Tokyo, 1989.

2 H.Kraus, Thin Elastic Shells”, John Wiley & Sons, Inc., New York, 1987.

3 L.R. Calcote, “Analysis of Laminates Structures”, Van Nostrand Reinhold, 1989.

4 W.Flugge, “Stresses in Shells”, II Edition Springer Verlag Co., New York, 1983.

5 A.L.Goldenvizier, “Theory of Elastic Thin Shells”, Pergamon Press, New York, 1981.