SCHEME &SYLLABUS

OF

B Tech Aerospace Engineering

(3^{RD} TO 8^{TH} Semester)

for affecting Batch 2012

SEMESTER III

CODE	TITLE OF COURSE	LOAD ALLOCATION			MAXIMUM MARKS		TOTAL MARKS
		L	T	P	INTERNAL	EXTERNAL	
AM-201	MATHEMATICS-III	5	1	-	40	60	100
ASPE-201	FLUID MECHANICS & MACHINERY	4	1	-	40	60	100
ANE-202	AERODYNAMICS-I	5	1	-	40	60	100
ME-201	STRENGTH OF MATERIALS- I	4	1	-	40	60	100
ASPE-202	INTRODUCTION TO AEROSPACE ENGINEERING	5	1	-	40	60	100
ASPE-203	WORKSHOP TRAINING OF 4 WEEKS DURATION AFTER SECOND SEMESTER				60	40	100
PRACTICALS							
ME-211	STRENGTH OF MATERIALS LAB	-	-	2	30	20	50
ASPE-204	FLUID MECHANICS & MACHINERY LAB	-	-	2	30	20	50
	TOTAL	23	5	4	320	380	700

SEMESTER IV

CODE	TITLE OF COURSE	LOAD ALLOCATION			MAXIMUM MARKS		TOTAL MARKS
		L	T	P	INTERNAL	EXTERNAL	
ANE-204	NUMERICAL ANALYSIS	5	1	-	40	60	100
ANE-205	THERMODYNAMICS	4	1	-	40	60	100
ASPE-206	AEROSPACE STRUCTURES-I	4	1	-	40	60	100
ASPE-207	AEROSPACE PROPULSION-I	5	1	-	40	60	100
ME-203	THEORY OF MACHINES-I	5	1	-	40	60	100
PRACTICALS							
ASPE-209	THERMODYNAMICS LAB	-	-	2	30	20	50
ASPE-210	AEROSPACE STRUCTURES LAB	-	-	2	30	20	50
	GENERAL FITNESS	-	-	-	100	-	100
	TOTAL	23	5	4	360	340	700

SEMESTER V

CODE	TITLE OF COURSE	LOAD ALLOC		MAXIMUM MARKS		TOTAL MARKS
		T	P	INTERNAL	EXTERNAL	
ASPE-301	PERFORMANCE STABILITY AND CONTROL	1	-	40	60	100
ASPE-302	AEROSPACE MATERIALS	1	-	40	60	100
ASPE-303	AERODYNAMICS-II	1	-	40	60	100
ASPE-304	CONTROL ENGINEERING	1	-	40	60	100
ASPE-305	AEROSPACE PROPULSION -II	1	-	40	60	100
ASPE-306	INDUSTRIAL TRAINING OF 6 WEEKS UNDERGONE AFTER 4TH SEMESTER			60	40	100
PRACTICALS						
ASPE-307	AERODYNAMICS LAB	-	2	30	20	50
ASPE-308	PROPULSION LAB	-	2	30	20	50
	TOTAL	5	4	320	380	700

SEMESTER VI

CODE	TITLE OF COURSE	LOAD ALLOCATI			MAXIMUM MARKS		TOTAL MARKS
		L	T	P	INTERNAL	EXTERNAL	
ASPE-309	COMPUTATIONAL FLUID DYNAMICS	5	1	-	40	60	100
ASPE-310	SATELLITES AND SPACE SYSTEM DESIGNS	4	1	-	40	60	100
ASPE-311	VIBRATION AND STRUCTURAL DYNAMICS	5	1	-	40	60	100
ASPE-312	AEROSPACE STRUCTURES-II	4	1	-	40	60	100
ASPE-313	FINITE ELEMENT METHODS	5	1	-	40	60	100
	GENERAL FITNESS				100	-	100
PRACTICALS							
ASPE-314	**MODELING AND ANALYSIS LABORATORY**	-	-	2	30	20	50
ASPE-315	**SIMULATION LABORATORY**	-	-	2	30	20	50
	TOTAL	23	5	4	320	380	700

SEMESTER VII/VIII

CODE	TITLE OF COURSE	LOAD ALLOCATI			MAXIMUM MARKS		TOTAL MARKS
		L	T	P	INTERNAL	EXTERNAL	
ASPE-401	AEROSPACE QUALITY ASSUARANCE	5	1	-	40	60	100
ASPE-402	AEROELASTICITY	4	1	-	40	60	100
ASPE-403	SPACE MECHANICS AND LAUNCH VEHICLES	5	1	-	40	60	100
ASPE-404	AVIONICS	4	1	-	40	60	100
	ELECTIVE*	5	1	-	40	60	100
PRACTICALS							
ASPE-405	FLIGHT DYNAMICS LAB	-	-	2	30	20	50
ASPE-406	STRUCTURES LAB	-	-	2	30	20	50
ASPE-407	PROJECT						
	TOTAL	23	5	4	320	380	700

***One subject out of the following List of Elective Subjects is to be selected by the candidate**
ASPE-408: GUIDANCE AND NAVIGATION
ASPE-409: THEORY OF PLATES AND SHELLS
ASPE-410: APPLIED GAS DYNAMICS

SEMESTER VIII/VII

CODE	TITLE OF COURSE	L	T	P	MAXIMUM MARKS		TOTAL MARKS
					INTERNAL	EXTERNAL	
INDUSTRIAL TRAINING INCLUDING 2-WEEKS FLIGHT TRAINING					600	400	1000

SEMESTER III

AM-201 MATHEMATICS-III

1. Fourier Series- Periodic functions, Euler's formula. Even and odd functions, half range expansions, Fourier series of different wave forms.

2. Laplace Transforms- Laplace transforms of various standard functions, properties of Laplace transforms, inverse Laplace transforms, transform of derivatives and integrals, Laplace transform of unit step function, impulse function, periodic functions, applications to solution of ordinary linear differential equations with constant coefficients, and simultaneous differential equations.

3. Special Functions Power series solution of differential equations, Frobenius method, Legendre' equation, Legendre polynomial, Bessel's equation, Bessel functions of the first and second kind. Recurrence relations, equations reducible to Bessel's equation, Error function and its properties

4. Partial Differential Equations Formation of partial differential equations, Linear partial differential equations, homogeneous partial differential equations with constant coefficient Applications: Wave equation and Heat conduction equation in one dimension, Two dimensional Laplace equation, solution by the method of separation of variables. Laplacian in polar coordinates

5. Functions of Complex Variable Limits, continuity, derivative of complex functions, analytic function, Cauchy-Riemann equation, conjugate functions, harmonic functions; Conformal Mapping: Mapping of a complex function, conformal mapping, standard transforms, mapping of standard elementary transformations, complex potential, applications to fluid flow problems; Complex Integration : Line integrals in the complex plane, Cauchy's theorem, Cauchy's integral formula and derivatives of analytic function. Taylor's and Laurent's expansions, singular points, poles, residue, complex integration using the method of residues, evaluation of real integrals by contour integration

SUGGESTED READING / BOOKS:

- Advanced Engineering Mathematics by Kreyszing Erwin ; Wiley Eastern, New Delhi
- Higher Engineering Mathematics by BS Grewal : Khanna Publishers, New Delhi.
- Numerical Solutions of Differential Equations by NK Jain ; Prentice Hall, Delhi.
- Differential Equations by Sharma and Gupta ; Krishna Prakashan Media (P) Ltd., Meerut.

ASPE-201 FLUID MECHANICS & MACHINERY

PART A

1. **BASIC CONCEPTS AND PROPERTIES** Fluid – definition, distinction between solid and fluid ,Units and dimensions, Properties of fluids - density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension
   Fluid statics: concept of fluid static pressure, absolute and gauge pressures , pressure measurements by manometers and pressure gauges.

2. **FLIUD KINEMATICS AND FLUID DYNAMICS** Fluid Kinematics - Flow visualization , lines of flow ,types of flow , velocity field and acceleration , continuity equation, streamline , stream function , velocity potential function, circulation ,flow net.
   Fluid dynamics - equations of motion ,Euler's equation along a streamline , Bernoulli's equation , applications , Venturi meter, Orifice meter, Pitot tube , dimensional analysis - Buckingham's π theorem- applications , similarity laws and models.

PART B

3. HYDRAULIC TURBINES Fluid machines: definition and classification, exchange of energy , Euler's equation for turbo machines , Construction of velocity vector diagram's , head and specific work , components of energy transfer , degree of reaction.
Hydro turbines: definition and classifications , Pelton turbine , Francis turbine , propeller turbine , Kaplan turbine , working principles , velocity triangles , work done , specific speed , efficiencies , performance curve for turbines.

4. HYDRAULIC PUMPS-Pumps: definition and classifications, Centrifugal pump: Classifications, working principles, velocity triangles, specific speed, efficiency and performance curves. Reciprocating pump: classification, working principles, indicator diagram, work saved by air vessels and performance curves, cavitations in pumps, rotary pumps, working principles of gear and vane pumps.

SUGGESTED READING /BOOKS:

- Fundamentals of Aerodynamics, Anderson J.D., McGraw-Hill Book Co., New York, 1985.
- Aerodynamics for Engineering students, Houghton E.L. and Carruthers N.B., Edward Arnold Publishers Ltd., London, 1989.
- Theoretical aerodynamics, Milne Thomson L.H., Macmillan, 1985.

ANE -202 AERODYNAMICS- I

1. Introduction

Fluid statics, Pascal's law, Continuum and free molecular flows, Invisid and viscous flows, incompressible and compressible flows. Newtonian and Non-Newtonian flows. Pitot static tube, measurement of air-speed, pressure coefficient. Aerodynamic force and moments, Dimensional analysis, non-dimensional parameters, M, Re, Fr etc., flow similarity.

2. Description of Fluid Motion

Lagrangian and Eulerian methods, Description of properties in a moving fluid, local and material rate of change. Streamlines, Pathlines, Streaklines, Reynolds Transport theorem, Vorticity and circulation. Laws of vortex motion. Translation, rotation and rate of deformation of fluid particles.

3. Equations of Fluid Motion

Equation of conservation of mass for control volume, special form of equation of conservation of mass, differential form of equation of conservation of mass Euler's and Navier-Stoke equations. Derivation of Bernoulli's equation for Invisid and viscous flow fields. Momentum equation and angular momentum equation in integral form.

4. Invisid-Incompressible Flow

Condition on velocity for incompressible flow. Laplace's equations. Potential function, stream function. Basic elementary flows: Uniform flows, source flow, Doublet flow and Vortex flow. Superimposition of elementary flows, Non-lifting and lifting flow over a circular cylinder, comparison with real flow over circular cylinder. Kutta-Jaukowski theorem, generation of lift.

5. Introduction to Viscous Flow

Qualitative aspects of viscous flows, viscosity and thermal conductivity. Phenomenon of separation. Navier-Stokes equation; Viscous flow energy equation. Some exact solutions of Navier-Stokes equations: plane Poiseuille flow , Couette flow, Hagen-Poiseuille flow and Hele-Shaw flow

6. Introduction to Incompressible Boundary Layer

BL concept, BL properties, derivation of Prandtl's BL equations, Blasius solution, Karman's Integral equation. Turbulent BL over a plate, skin friction drag, BL control.

SUGGESTED READING/ BOOKS:

- Fundamentals of Aerodynamics, John D.Anderson(Jr.) , 2nd Ed.McGraw Hill
- Fluid Mechanics and its Applications, Gupta and Gupta, Wiley Eastern ,1960
- Boundary Layer Theory, H.Schlichting , 6th Ed. McGraw Hill ,1986
- Fluid Mechanics: Frank M.White 2nd Ed. McGraw Hill,1986

ME-201 STRENGTH OF MATERIALS – I

1. Simple stresses and strains : Concept of stress and strain; St. Vernants principle, stress and strain diagram, Hooke's law, Young's modulus, Poisson ratio, stress at a point, stress and strains in bars subjected to axial loading. Modulus of elasticity, stress produced in compound bars subject to axial loading. Temperature stress and strain calculations due to applications of axial loads and variation of temperature in single and compound bars. Compound stress and strains, the two dimensional system; stress at a point on a plane, principal stresses and principal planes; Mohr's circle of stress; ellipse of stress and their applications. Generalized Hook's Law, principal stresses related to principal strains

2. Bending moment and shear force diagrams: S.F and B.M definitions. BM and SF diagrams for cantilevers, simply supported beams with or without overhangs and calculation of maximum BM and SF and the point of contra flexure under the following loads:
a. Concentrated loads
b. Uniformity distributed loads over the whole span or part of span
c. Combination of concentrated loads (two or three) and uniformly distributed loads
d. Uniformity varying loads
e. Application of moments
f. Relation between rate of loading, shear force and bending moment

3. Theory of bending stresses in beams due to bending: assumptions in the simple bending theory, derivation of formula: its application to beams of rectangular, circular and channel, I & T Sections,: Combined direct and bending stresses in aforementioned sections, composite / flitched beams.

4. Torsion: Derivation of torsion equation and its assumptions. Applications of the equation to the hollow and solid circular shafts, torsional rigidity, combined torsion and bending of circular shafts principal stress and maximum shear stresses under combined loading of bending and torsion, analysis of close-coiled-helical springs.

5. Thin cylinders and spheres : Derivation of formulae and calculation of hoop stress, longitudinal stress in a cylinder, effects of joints, change in diameter, length and internal volume; principal stresses in sphere and change in diameter and internal volume

6. Columns and struts: Columns and failure of columns: Euler's formulas; Rankine- Gordon's formula, Johnson's empirical formula for axially loaded columns and their applications.

7. Slope and deflection: Relationship between moment, slope and deflection, Moment area method; method of integration; Macaulay's method: Use of all these methods to calculate slope and deflection for the following:
a) Cantilevers
b) Simply supported beams with or without overhang
c) Under concentrated loads, uniformly distributed loads or combination of concentrated and uniformly distributed loads

SUGGESTED READING/ BOOKS:

- Strength of Materials by Ferdinand P Singer and Andrew Pytel, Harper and Row H.
- Kogakusha Publishers, New York

- Mechanics of Materials by SI Version, end edition by Ferdinand P. Beer and E
- Russel Johnston (Jr); McGraw Hill, India
- Mechanics of Materials-SI Version 2nd Edition by EP Popov, Prentice Hall India
- Introduction to Solid Mechanics by D.H Shames, Prentice Hall Inc.
- Elements of strength of Materials by Timoshenko and Young
- Strength of Materials by DS Bedi; Khanna book Publishing Company, New Delhi.
- Strength of materials by R.S Lehri and A.S. Lehri, S.K Kataria and Sons.

ASPE-202 INTRODUCTION TO AEROSPACE ENGINEERING

PART A

1. HISTORICAL EVALUATION

History of Aviation, Early Development of Airplanes, Biplanes and Monoplanes, History of Spaceflight, Development of Space Vehicle, Classification of Duct Jet Propulsion, Rocket Propulsion, Advance Propulsion and Applications.

2. CONFIGURATIONS

Anatomy of flight vehicles, Components of an airplanes and their function, Configuration of space vehicle, Earth's atmosphere and gravitational field, Bluff bodies v/s Streamlined body, Airfoil, Lift generation, Significance of L/D ratio, Aerodynamic forces.

3. PROPULSION

Classification and Essential features of propulsion, Jet propulsion, General characteristics of rocket engines, Theory of propulsion, Elementary gas dynamics, Spacecrafts and Aircraft performance.

PART B

4. AEROSPACE STRUCTURES AND MATERIALS

General types of Construction and Structural Layout, Flight Envelope and V-N Diagrams, Monocoque, Semimonocoque, Corrugated, Sandwich Structure, Reinforced and Honeycomb Structures, Geodesic Construction, Aerospace Materials, Metallic and Non-Metallic Materials, Uses of Aluminum Alloy, Titanium, Stainless Steel, Composite and Ceramic Materials

5.INSTRUMENTS AND NAVIGATION

Basic Instrumentation, Electronics (DC Electronics, AC Electronics, Semiconductors, Electro-Optics and Digital Electronics), Sensing Devices, Bridge Circuits, Optical Devices and Introduction to Computer Based Data Acquisition, Measurements in Aerodynamics, Flight Structures, Flight Control, Principles of Navigation, Celestial, Radio, and Inertial Navigation Schemes, Navigational and Guidance Requirements for Orbital, Planetary, and Atmospheric Entry Missions

SUGGESTED READING/ BOOKS:

- Fundamentals of Flight, Shevel, Prentice Hall, 1989.
- Principle of Guided Missile Design , Merrill G, D. Van Nostrand Co., INC., 1977
- Introduction to Flight, Anderson J. D., McGraw-Hill, 2000.
- Flight without Formulae , Kermode A. C., Pitman, 1970

ME-211 STRENGTH OF MATERIALS LAB

1. To perform tensile test in ductile and brittle materials and to draw stress-strain curve and to determine various mechanical properties.
2. To perform compression test on C.I. and to determine ultimate compressive strength.
3. To perform shear test on different materials and determine ultimate shear strength.
4. To perform any one hardness test (Rockwell, Brinell & Vicker's test) and determine hardness of materials.
5. To perform impact test to determine impact strength.
6. To perform torsion test and to determine various mechanical properties.
7. Study of performance of Fatigue & Creep tests
8. To perform bending test on beam (wooden or any other material) and to determine the Young's modulus and Modulus of rupture
9. To perform Torsion test and close coiled helical spring in tension and compression and to determine modulus of rigidity/stiffness
10. Determination of Bucking loads of long columns with different end conditions.

ASPE-204 FLUID MECHANICS & MACHINERY LAB

1. To determine the metacentric height of a floating vessel under loaded and unloaded conditions.
2. To study the flow through a variable area duct and verify Bernoulli's energy equation.
3. To determine the coefficient of discharge for an obstruction flow meter (venturimeter/ orifice meter)
4. To determine the discharge coefficient for a Vee- notch or rectangular notch.

5. To study the transition from laminar to turbulent flow and to ascertain the lower critical Reynolds number.
6. To determine the hydraulic coefficients for flow through an orifice.
7. To determine the friction coefficients for pipes of different diameters.
8. To determine the head loss in a pipe line due to sudden expansion/ sudden contraction/ bend.
9. To determine the velocity distribution for pipeline flow with a pitot static probe

SEMESTER IV

ANE- 204 NUMERICAL ANALYSIS

1. Errors: Computer arithmetic, Errors in numerical calculations, Absolute, relative and percentage errors, Round off and truncation errors, Error propagation, Loss of significant digits, Errors in series approximation.

2. Solution Of Equations: Bisection method, Fixed point iteration and its convergence, Acceleration of convergence using Aitken's method; Regula-Falsi, Newton-Raphson, Generalized Newton's, Chebyshev's and Halley's methods.

3. Interpolation: Lagrange Interpolation, Newton's divided difference interpolation, Finite differences, Newton's and Gauss' difference formulae, Spline interpolation.

4. Numerical Differentiation & Integration: Differentiation using differences, Integration using Trapezoidal rule, Simpson's 1/3 rule, Newton-Cote's formula, Gaussian Quadrature.

5. Solution Of Linear System Of Equations: Direct methods - Gauss elimination, Partial pivoting, Complete pivoting, Gauss-Jordan and factorization methods, Solution of tridiagonal systems. Iterative methods-Gauss Siedal and Jacobi's methods, Convergence, Ill conditioning, Eigen values by iteration, Jacobi's methods

6. Numerical Methods For Differential Equations: Solution of first order differential equations using Euler's method, modified Euler's method and Runge-Kutta 4th order method, Predictor- Corrector methods (Adam's and Milne's method), Simultaneous differential equations of first order, Finite difference method.

7. Numerical Methods For Partial Differential Equation: Finite difference approximation to derivatives, solution to Laplace equation, Jacobi's method, Gauss-Siedel method.

SUGGESTED READING/BOOKS:

- Introductory Methods of Numerical Analysis: S.S. Sastry, Prentice Hall India.
- Numerical Methods for Mathematics, Science and Engineering: Mathews, Prentice Hall.
- An Introduction to Numerical Analysis: Atkinson, John Wiley.

ANE- 205 THERMODYNAMICS

1. Basic Concepts: Macroscopic and Microscopic approach, Concept of Continuum, Thermodynamic System, Surrounding and Boundary, Thermodynamic Equilibrium, State, Path, Process, cycle, Quasi-static Process, Reversible and Irreversible Process, Working Substance. Thermodynamic Properties like Pressure, Volume and Temperature, Zeroeth Law of Thermodynamics. Temperature Scales, Concept of Heat and work in Thermodynamics.

2. First Law Of Thermodynamics: Joule's Paddle wheel Experiment; Mechanical Equivalent of Heat, First Law for a closed system undergoing a Cycle, First Law for a closed system undergoing a change of state. Different forms of stored Energy, Enthalpy, Energy of an isolated System, Perpetual Motion, Machine of First kind.

3. First Law Applied To Flow Processes: Flow Process and Control Volume, flow work, Steady and Unsteady Flow Process, Steady Flow Energy Equation, Throttling Process, Flow Work and Non-Flow work, Variable flow Processes, Limitation of First Law.

4. Second Law Of Thermodynamics: Qualitative Difference between Heat and Work, Thermal Reservoir, Statements of 2nd Law by Max.Planck and Claussius, Equivalence between two statements, Energy Analysis of Heat Engine, Refrigerator and Heat Pump Reversibility and Irreversibility, Causes of Irreversibility, Carnot Theorem, Carnot cycle, Absolute Thermodynamic Temperature, Efficiency of the Reversible Heat Engine, Equality of Ideal Gas Temperature and Kelvin Temperature.

5. Entropy: Classius Theorem, Classius Inequality and concept of Entropy, Entropy change in an Irreversible Process, Application of Entropy Principle, Entropy Transfer with Heat Flow, Entropy generation in closed and open system, Thermodynamics Equations relating properties of System, Reversible Adiabatic work in a Steady flow System. Entropy and direction, Entropy and disorder.

6. Available Energy And Availability: Available Energy referred to a cycle, Quality of work, Maximum work in Reversible Process, Useful work, Dead State, Availability, Second Law Efficiency.

7. Gas Power Cycles: Air Standard efficiency, Mean Effective Pressure, Otto, Diesel, Dual, Brayton, Stirling and Ericson Cycle, Comparison of cycles

8. Properties Of Gases And Gas Mixture: Equation of state of a gas, Properties of Mixture of gases, Internal Energy, Enthalpy and Specific heat of gas, mixtures, Entropy of gas Mixtures.

9. Properties Of Pure Substances: H-S, T-S, P-V, P-T, diagram for a Pure Substance, Properties of Pure substance with special reference to water, Steam and its formation, Wet Dry, Saturated and Superheated Steam, sensible, Latent heat, Dryness fraction and its determination, Separating and Throttling calorimeter Enthalpy, Entropy and Internal Energy of Steam. Use of Steam Table and Mollier Diagram, Basic Thermodynamic Processes of Steam in Closed and Open System and their representation on P-V and H-S chart.

10. Vapour Power Cycle: Carnot and Rankine Steam Power Cycle, Actual Vapour cycle
Processes, Comparison of Carnot and Rankine cycle, Mean Temperature of Heat Addition, Reheat Cycle, Ideal Regenerative Cycle, Reheat Regenerative Cycle, Feed Water Heater, Characteristics of an Ideal working fluid in Vapour Power cycle.

11. General Thermodynamic Relations: Maxwell's Equation, Tds Equations, Ratio of specific heats, Joule Kelvin Effect, Classius-Clapeyron Equations, Gibb Phase Rule.

SUGGESTED READING/BOOKS:

- Engineering Thermodynamics: P.K. Nag, McGraw Hill
- Engineering Thermodynamics : Gordon Rogers & Yon Machew
- Thermodynamics :Yunus Cengel and Mike Boles, McGraw Hill
- Thermodynamics: Arora, Tata McGraw Hill.

ASPE-206 AEROSPACE STRUCTURE-I

PART A

1. Basic Elasticity: Equations of Equilibrium ; 2D stress problem, Airy stress functions

2.STATICALLY DETERMINATE STRUCTURES

Analysis of plane truss, Method of joints, 3-D Truss, Plane frames

3. ENERGY METHODS

Strain Energy due to axial bending and Torsional loads, Castigliano's theorem, Maxwell's Reciprocal theorem, Unit load method, application to beams, trusses, frames, rings, etc.

PART B

4. COLUMNS

Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, Southwell plot, and Beam column.

5. FAILURE THEORY

Maximum Stress theory, Maximum Strain Theory , Maximum Shear Stress Theory, Distortion Theory , Maximum Strain energy theory , Application to aircraft Structural problems.

6. Aerospace vehicle structure: Basic structure of rockets missiles and satellites

SUGGESTED READING/ BOOKS:

- Analysis of Aircraft Structures – An Introduction, Donaldson, B.K., McGraw-Hill, 1993.
- Theory of Elasticity, Timoshenko, Goodier Tata McGraw –Hill
- Advanced solid mechanics L.S. Srinath, McGraw –Hill

ASPE-207 AEROSPACE PROPULSION-I

PART A

1. INTRODUCTION TO AIRCRAFT PROPULSION
Introduction to Propulsion, Basic Thermodynamics, Fundamental Equations, Types of Aircraft Engines, Performance Parameters, Thrust Equation, Factors Affecting Thrust and Efficiencies.

2. STEADY ONE DIMENSIONAL FLOW
One Dimensional Flow of a Perfect Gas, Isentropic Flow, Non-Isentropic Flow, Frictionless Constant Area Flow, Constant Area Flow with Friction and without Friction, Normal Shock and Oblique Shocks

3. FUNDAMENTALS OF GAS TURBINE ENGINES
Working Principle of Gas Turbine Engine, Gas Turbine Cycle, Turboprop, Turbofan and Turbojet Engines, Thrust and Efficiency, Methods of Thrust Augmentation, Engine Performance Characteristics.

PART B

4. FUNDAMENTALS OF ROCKET PROPULSION
History of Rocket Propulsion, Types of Rockets, Basic Configurations and Applications, Types of Missiles and their Structure, Heat Transfer and Cooling System in Rocket , Classification of Chemical Rocket Propulsion System.

5. PERFORMANCE OF AEROSPACE VEHICLES
Static Performance, Vehicle Acceleration, Performance Characteristics, Nozzle, Solid, Liquid and Hybrid Rocket and their Propellants

SUGGESTED READING/ BOOKS:

- Mechanics & Thermodynamics of Propulsion, Hill P.G. & Peterson, C.R. Addison, Wesley Longman INC, 1999.
- Rocket Propulsion Elements, G.P Sutton & O. Biblarz, John Wiley & Son Inc., 2001.
- Gas Turbine Theory, Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H., Longman, 1989.
- Aero thermodynamics of Aircraft Engine Components, Oates G.C., AIAA Education Series, New York, 1985.
- Gas Turbine, Jet and Rocket Propulsion, Mathur M.L. and Sharma, R.P., Standard Publishers & Distributors, Delhi, 1999.

ME-203 THEORY OF MACHINES-I

Detailed Contents

1. **Basic Concept of Machines :**
   Link mechanism, kinematic pair and chain, principles of inversion, inversion of a four bar chain, slider-crank-chain, double slider-crank-chain and their inversions, kinematic pairs, Graphical(relative velocity vector and instantaneous center methods) and Analytical methods for finding: Displacement, velocity, and acceleration of mechanisms (including Corliolis)

2. **Lower Pairs**: Universal joint, calculation of maximum torque, steering mechanisms including Ackerman and Davis approximate steering mechanism, engine indicator, Pentograph, Straight line mechanisms.

3. **Belts, Ropes and Chains:**
   Material, types of drives, idle pulley, intermediate or counter shaft pulley, angle and right angle drive, quarter turn drive, velocity ratio, crowning shaft pulley, loose and fast pulley, stepped or cone pulleys, ratio of tension on tight and slack sided of belts, HP transmitted by belts including consideration of creep and slip, centrifugal tensions and its effect on HP transmitted. Use of gravity, idle, flat, V-belts and rope materials, Length of belt, rope and chain drives, type and cone type.

4. **Cams:**
   Types of cams and follower, definitions of terms connected with cams, displacement velocity and acceleration diagrams for cam followers. Analytical and Graphical design of cam profiles with various motions (SHM, uniform acceleration and retardation, cycloidal). Analysis of follower motion for circular convex, tangent cam profiles. Calculation of pressure angle.

5. **Friction Devices:**
   Concepts of frictions and wear related to bearing and clutches. Types of brakes, Principle of function of Brakes of various types. Braking of front and rear tyres of a vehicle, Problems to determine braking capacity, Types of dynamometers (absorption & transmission).

6. **Flywheels :**
   Turning moment and crank effort diagrams for reciprocating machines, Fluctuations of speed, coefficient of fluctuation of speed and energy, Determination of flywheel mass and dimensions for engines and Punching Machines.

7. **Governors**:
   Function, types and characteristics of governors, Watt, Porter and Proell governor, Hartnell and Willson-Hartnell, spring loaded governors, Simple numerical problems on these governors, Sensitivity, stability, isochronisms and hunting of governor, Governor effort and power controlling force curve, effect of sleeve friction

SUGGESTED READING/ BOOKS:

- Jagdish Lal, Theory of Mechanisms & Machines: Metropolitan Book Co. Pvt.Ltd, New Delhi.
- S. S. Rattan, Theory of Machines: Tata McGraw Hill, New Delhi
- Thomas Beven, Theory of Machines : Longman's Green & Co., London
- W. G. Green,Theory of Machines : Blackie & Sons, London
- W. G. Green,Theory of Machines : Shigley, Mcgraw Hill , New York

ASPE-209 THERMODYNAMIC LAB

1. Performance test on a 4-stroke engine
2. Valve timing of a 4 – stroke engine and port timing of a 2 stroke engine
3. Determination of effectiveness of a parallel flow heat exchanger
4. Determination of effectiveness of a counter flow heat exchanger
5. Determination of the viscosity coefficient of a given liquid
6. COP test on a vapour compression refrigeration test rig
7. COP test on a vapour compression air-conditioning test rig
8. Study of a Gas Turbine Engine.
9. Determination of Conductive Heat Transfer Coefficient.
10. Determination of Thermal Resistance of a Composite wall.

ASPE-210 AEROSPACE STRUCTURES LAB

1. Determination of Young's modulus of steel using mechanical extensometers.
2. Determination of Young's modulus of aluminum using electrical extensometers
3. Determination of fracture strength and fracture pattern of ductile materials
4. Determination of fracture strength and fracture pattern of brittle materials
5. Stress Strain curve for various engineering materials.
6. Deflection of beams with various end conditions.
7. Verification of Maxwell's Reciprocal theorem & principle of superposition
8. Column – Testing
9. South well's plot.
10. Riveted Joints.

SEMESTER V

PERFORMANCE, STABILITY AND CONTROL-ASPE-301

1. THRUST AND DRAG OF AIRPLANE

Equilibrium conditions. Drag components. Drag polar from low speed to high speeds. Flight boundary. Variation of thrust, power and SFC with velocity and altitudes for air breathing engines. Propeller charts.

2. AIRCRAFT PERFORMANCE IN STEADY FLIGHT

Performance of airplane in level flight. Power available and power required curves. Thrust available and thrust required curves. Generalized power required curves. Generalized thrust required curves. Maximum speed in level flight. Conditions for minimum drag and power required. Range and endurance. Climbing and gliding flight (Maximum rate of climb and steepest angle of climb; minimum rate of sink and shallowest angle of glide).

3. AIRCRAFT PERFORMANCE IN ACCELERATED FLIGHT

Take-off and landing distances. Acceleration in climb. Turning performance (Turning rate, turn radius). Bank angle and load factor. Power required at various angles of bank. Limitations of pull up and push over. Design performance. Generalized design chart.

4. STATIC LONGITUDINAL STABILITY AND CONTROL

Stability criteria. Contribution of airframe components. Trim condition. Power effects. Static margin. Stick free and stick fixed neutral points. Stick force gradient. Airplane stability in accelerated flight. Influence of C.G. location. Hinge moment coefficient. Determination of neutral points and maneuver points from flight test. Trim runaway.

5. STATIC DIRECTIONAL STABILITY AND CONTROL

Definition of directional stability. Weather cocking effect. Contribution of airframe components. Directional control. Dorsal fin. One engine inoperative condition. Rudder lock.

6. STATIC LATERAL STABILITY AND CONTROL

Roll stability. Dihedral effect. Lateral control. Effect of wing sweep, flaps, and power-on dihedral effect. Coupling between rolling and yawing moments. Adverse yaw effects. Aileron reversal. Balancing the aileron. Flaprons and elevons.

7. DYNAMIC LONGITUDINAL STABILITY

Dynamic longitudinal stability: types of modes of motion. Equations of longitudinal motion – small disturbance theory. Estimation of longitudinal stability derivatives. Routh's criteria.. Phugoid motion. Factors affecting period and damping of oscillations. Effect of wind shear. Phugoid stabilization. Flying qualities in pitch. Cooper-Harper Scale.

8. DYNAMIC LATERAL AND DIRECTIONAL STABILITY

Response to aileron step-function, side-slip excursion. Dutch roll and Spiral instability. Auto- rotation and spin. Stability derivatives for lateral and directional dynamics. Roll-Pitch-Yaw Inertial coupling.

TEXT BOOKS:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2007.

REFERENCE BOOKS:

1. Bandu N. Pamadi, `Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.
2. Barnes W. McCormick, `Aerodynamics, Aeronautics, and Flight Mechanics`, John Wiley & Sons, Inc. 1995.
3. Thomas R. Yechout, `An introduction to Aircraft Flight Mechanics`, AIAA educational Series; 2003.

AEROSPACE MATERIALS- ASPE -302

1. INTRODUCTION

Properties of Flight Vehicle Materials, Importance of strength/weight ratio of materials for Aerospace Vehicles structures, Importance of temperature variations, factors affecting choice of
material for different parts of airplane.

2. LIGHT METAL ALLOYS

Aluminum alloys, heat treatment, High strength and high corrosion alloys. Magnesium alloys and their properties, Heat treatment, Application of these alloys to Aerospace Vehicles.

3.AIRCRAFT STEELS

Classical of alloys steels, Effect of alloying elements, Carbon Steel V/S Alloys. Magnesium alloys and their properties, Heat treatment, Application to Aerospace Vehicle of these alloys.

4. HIGH STRENGTH AND HEAT RESISTANT ALLOYS

Classification of heat resistant materials, Iron, Nickel and Cobalt base alloys, Refractory materials, Ceramics, Titanium and its alloys, properties of Inconel Monal & K-Monal, Nimonic and Super Alloys; Application to Aerospace Vehicles

5. METAL JOINING PROCESSES

Weldability, standard welding practices e.g. gas welding, resistance welding. Welding of light alloys, Riveting.

6. COMPOSITE MATERIALS

Definition, classification and characteristics of composite materials - fibrous composites, laminated composites, particulate composites. Properties and types of Reinforcement and Matrix materials

7. FIBER REINFORCED PLASTIC PROCESSING

Lay up and curing, fabricating process - open and closed mould process - hand lay up techniques structural laminate bag molding, production procedures for bag molding.

8. ADVANCED PROCESSING TECHNIQUES AND APPLICATION OF COMPOSITES

Filament winding, pultrusion, pulforming, thermo - forming, injection, injection molding, liquid molding, blow molding, Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.

Text Books :

1. Composites Science and Engineering, K.K Chawla, Springer Verlag, 1998.
2. Workshop technology: WAJ Chapman, Replika Press Pvt. Ltd.
3. Aircraft Material and Processes: G F Titterton, Himalayan Books, New Delhi.
4. Advanced Composite materials: Lalit Gupta, Himalayan Books, New Delhi

AERODYNAMICS – II ASPE-303

1. INTRODUCTION TO TWO-DIMENSIONAL PANEL METHODS

Non-lifting flows over arbitrary bodies, source panel method, lifting flows over arbitrary bodies, vortex panel method, some examples.

2. INCOMPRESSIBLE FLOWS OVER FINITE WINGS

Downwash, Induced drag, vortex filament, the Biot-Savart Law, Prandtl's lifting line theory and its limitations, Elliptic lift distribution.

3. SUBSONIC LINEARIZED FLOW OVER AIRFOILS

Full velocity potential equation, linearized velocity potential equation and boundary condition, Prandtl-Glauret compressibility correction.

4. EFFECTS OF COMPRESSIBILITY

Critical Mach number; Drag-divergence Mach number, Sound Barrier, Transonic area rule, Introduction to shock-free airfoils.

5. APPLICATIONS OF FINITE WING THEORY

Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects.

6. BODIES OF REVOLUTION

Introduction to slender body theory, cylindrical coordinates, boundary conditions, pressure coefficient, Subsonic flow past a axially symmetric body at zero incidence and solution for a slender cone.

7. SWEPT WINGS AND HIGH-LIFT SYSTEMS

Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high - lift characteristics

8. VISCOUS FLOWS

Derivation of Navier-Stokes equation for two-dimensional flows, boundary layer approximations, laminar boundary equations and boundary conditions, Blasius solution, qualitative features of boundary layer flow under pressure gradients, Integral method, aspects of transition to turbulence, turbulent boundary layer properties over a flat plate at low speeds.

TEXT BOOKS:

1. **Fundamentals of Aerodynamics,** Anderson, Jr. J.D, Tata McGraw-Hill Publishing Co. Ltd., New Delhi, 2007. (Special Indian Edition).
2. **Boundary layer theory,** Schlichting, H,", McGraw Hill, New York 2004

REFERENCE BOOKS:

1. **Aerodynamics for Engineers,** Bertin, John J., Pearson Education Inc., 2002.
2. **Fluid Mechanics,** White, F.M., Mc Graw Hill Inc. New York, 1986
3. **Aerodynamics for Engineering Students,** Houghton E.L and Carpenter P.W., CBS Publications and Distributors,8 1993. (4^{th} Edition).

CONTROL ENGINEERING –ASPE-304

1. INTRODUCTION

Concept of automatic controls, open and closed loop systems, concepts of feedback, requirement of an ideal control system. Types of controllers– Proportional, Integral, Proportional Integral, Proportional Integral Differential controllers.

2. MATHEMATICAL MODELS

Transfer function models, models of mechanical systems, models of electrical circuits, DC and AC motors in control systems, models of thermal systems, models of hydraulic systems. Pneumatic system. Analogous systems: Force voltage, Force current.

3. BLOCK DIAGRAMS AND SIGNAL FLOW GRAPHS

Transfer Functions definition, function, block representation of system elements, reduction of block diagrams, Signal flow graphs: Mason's gain formula.

4. TRANSIENT AND STEADY STATE RESPONSE ANALYSIS

Introduction, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance in speed of response. System stability: Routh's-Hurwitz Criterion.

5. FREQUENCY RESPONSE ANALYSIS

Polar plots, Nyquist Stability Criterion, Stability Analysis, Relative stability concepts, phase and gain margin, M & N circles.

6. FREQUENCY RESPONSE ANALYSIS USING BODE PLOTS

Bode attenuation diagrams, Stability Analysis using Bode plots, Simplified Bode Diagrams.

7. ROOT LOCUS PLOTS

Definition of root loci, general rules for constructing root loci, Analysis using root locus plots.

8. CONTROL ACTION AND SYSTEM COMPENSATION

Series and feedback compensation, Physical devices for system compensation.

TEXT BOOKS:

1. **Modern Control Engineering:** Katsuhiko Ogata, Pearson Education, 2004.
2. **Control Systems Principles and Design**: M. Gopal, TMH, 2000

REFERENCE BOOKS:

1. **Feedback Control Systems:** Schaum's series 2001.
2. **Control systems:** I. J. Nagarath & M. Gopal, New age International publishers 2002.
3. **Automatic Control Systems** – B. C. Kuo, F. Golnaraghi, John Wiley & Sons, 2003.

AEROSPACE PROPULSION-ASPE-305

1. INTRODUCTION

Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles of internal combustion engine, Two – stroke and four – stroke piston engines, Gas- turbine engines, Cycle analysis of reciprocating engines and jet engines.,RAMJET Propulsion,SCRAMJET propulsion

2. FUNDAMENTALS OF GAS TURBINE ENGINES

Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet – Performance characteristics.

3. SUBSONIC AND SUPERSONIC INLETS FOR JET ENGINES

Internal flow and Stall in subsonic inlets – Boundary layer separation – Major features of external flow near a subsonic inlet – Relation between minimum area ratio and eternal deceleration ratio – Diffuser performance – Supersonic inlets – Starting problem on supersonic inlets – Shock swallowing by area variation – External declaration – Models of inlet operation.

4. COMBUSTION CHAMBERS

Classification of combustion chambers – Important factors affecting combustion chamber design – Combustion process – Combustion chamber performance – Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders – Numerical problems.

5. NOZZLES

Theory of flow in isentropic nozzles – Convergent / Convergent – divergent nozzles; Nozzle throat conditions – Nozzle efficiency – Losses in nozzles – Over expanded and under – expanded nozzles - Thrust reversal.

6. COMPRESSORS

Principle of operation of centrifugal compressor – Work done and pressure rise – Velocity diagrams – Diffuser vane design considerations – Concept of prewhirl – Rotation stall – Elementary theory of axial flow compressor – Velocity triangles – degree of reaction -Centrifugal and Axial compressor performance characteristics.

7. INTRODUCTION TO TURBINES

Types of turbines – Design considerations – Performance parameters - Basics of blade design principles.

8.DESIGN OF ROCKET MOTOR

Design of Solid ,Liquid and Hybrid propellant Rocket motors including Nozzle Designs.

TEXT BOOKS:

1. **Gas Turbine,** V. Ganesan, Tata McGraw Hill Pub. Co. Ltd., 1996.
2. **Mechanics & Thermodynamics of Propulsion,** Hill, P.G. & Peterson, C.R. Addison – Wesley Longman INC, 1999.

REFERENCE BOOKS:

1. **Gas Turbine Theory,** Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H. "Longman, 1989.
2. **Aero thermodynamics of Aircraft Engine Components,** Oates, G.C., , AIAA Education Series, New York, 1985.
3. **Gas Turbine, Jet and Rocket Propulsion,** Mathur, M.L. and Sharma, R.P., Standard Publishers & Distributors, Delhi, 1999.

AERODYNAMICS LABORATORY –ASPE-307

(Wind Tunnel is required)

LIST OF EXPERIMENTS

1. Calibration of a subsonic wind tunnel: test section static pressure and total head distributions.

2. Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds.

3. Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds

4. Tuft flow visualization on a wing model at different angles of incidence at low speeds: identify zones of attached and separated flows.

5. Surface pressure distributions on a two-dimensional circular cylinder at low speeds and calculation of pressure drag.

6. Surface pressure distributions on a two-dimensional symmetric airfoil at zero incidence at low speeds.

7. Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag.

8. Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey.

9. Calculation of total drag of a two-dimensional cambered airfoil at low speeds at incidence using pitot-static probe wake survey.

10. Measurement of a typical boundary layer velocity profile on the tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness.

ROPULSION LABORATORY-ASPE-308

LIST OF EXPERIMENTS

1. Study of an aircraft piston engine. (Includes study of assembly of sub systems, various components, their functions and operating principles)

2. Study of an aircraft jet engine (Includes study of assembly of sub systems, various components, their functions and operating principles)

3. Study of forced convective heat transfer over a flat plate.

4. Cascade testing of a model of axial compressor blade row.

5. Study of performance of a propeller.

6. Determination of heat of combustion of aviation fuel.

7. Study of free jet

8. Measurement of burning velocity of a premixed flame.

9. Fuel-injection characteristics

10. Measurement of nozzle flow.

VI SEMESTER

COMPUTATIONAL FLUID DYNAMICS -ASPE-309

1. INTRODUCTION

Insight into power and philosophy of CFD. CFD ideas to understand. CFD application. Need for parallel computers for CFD algorithms. Models of flows. Substantial derivative, Divergence of velocity

2. GOVERNING EQUATIONS

Continuity, Momentum and Energy equations; derivation in various forms. Integral versus Differential form of equations. Comments on governing equations. Physical boundary conditions. Forms of the governing equations particularly suited for CFD work : Shock fitting and Shock capturing methods. Generic form of equations.

3. MATHEMATICAL BEHAVIUOR OF PARTIAL DIFFERENTIAL EQUATIONS: THE IMPACT ON CFD

Classification of partial differential equations. Cramer rule and Eigen value method. Hyperbolic, parabolic and elliptic forms of equations. Impact on physical and computational fluid dynamics; case studies: steady inviscid supersonic flow; unsteady invisid flow; steady boundary layer flow; and unsteady thermal conduction.

4. DISCRETIZATION

Essence of discretization. Taylor series approach for the construction of finite-difference quotients. Higher order difference quotients. Up-wind differencing. Midpoint leap frog method. Reflection boundary condition. Difference equations. Explicit and Implicit approach: definition and contrasts. Errors and analysis of stability. Error propagation. Stability properties of Explicit and Implicit methods.

5. GRID GENERATION

Body –fitted coordinate system. Need for grid generation. Essential properties of grids. Types of grids (O-type, C-type and H-type). Various grid generation techniques - Algebraic, and Numerical grid generation. Elliptic grid generation. Structured, Un-structured grids, Adaptive grids, Grid collapse. Multi-Grid methods .Grid accuracies.

6. APPROPRIATE TRANSFORMATION

General transformation of equations. Metrics and Jacobians. Generic form of the governing flow equations with strong conservative form in the transformed space. Transformation of continuity equation from physical plane into computational plane; application of Grids stretching .

7. FINITE VOLUME TECHNIQUES

Finite Volume Discretization - Cell Centered Formulation. High resolution finite volume upwind Scheme. Runge - Kutta Time Stepping . Multi - Time –Step Integration scheme. Cell Vertex Formulation. Numerical dispersion.

8. CFD APPLICATION TO SOME PROBLEMS

Time and space marching. LAX-WENDROFF Technique . Relaxation technique. Point iterative mehod. Successive over-relaxation/under relaxation. Aspects of numerical dissipation and dispersion; artificial viscosity. The Alternating-Direction-(ADI) Implicit Technique. Approximate factorization scheme. Upwind schemes; Flux vector splitting.

TEXT BOOKS:

1. John D Anderson Jr. Computational Fluid Dynamics, `The Basics with Applications`, McGraw Hill International Edn; 1995.
2. Tapan K. Sengupta, `Fundamentals of Computational Fluid Dynamics`, Universities Press (India) Private Limited; 2005.

REFERENCES BOOKS:

1. F. Wendt (Editor), “Computational Fluid Dynamics - An Introduction”, Springer – Verlag, Berlin; 1992.
2. Charles Hirsch, “Numerical Computation of Internal and External Flows”, Vols. I and II. John Wiley & Sons, New York; 1988.
3. Jiyuan Tu, Guan Heng Yeoh, and Chaoqun Liu,` Computational Fluid Dynamics- A Practical Approach`, Elsevier Inc; 2008.

SATELLITES AND SPACE SYSTEM DESIGNS-ASPE-310

1. SPACE MISSION ANALYSIS AND DESIGN PROCESS

Space mission life cycle, Mission objectives, Mission needs, Mission requirements and constraints, Space environment and survivability, Space logistics and reliability, Orbital debris

2. SPACECRAFT CONFIGURATION AND STRUCTURAL DESIGN

Design requirements, Design process, Material solution, Analysis, Design verification, Impact protection, Configuration, The future of space structure.

3. THERMAL CONTROL OF SPACECRAFT

Thermal environment, Thermal balance, Thermal analysis, Thermal design, Thermal technology, Thermal design verification, Satellite thermal design

4. SPACECRAFT ATTITUDE, CONTROL AND INSTRUMENTATION

Basic launch vehicle consideration, Launch system selection process, Determining the spacecraft design envelope, Attitude requirements, kinematics, measurements, estimation and dynamics, Space control system, Telecommunication, Onboard systems, Science instruments, Navigation.

5. SPACECRAFT DESIGN MANAGEMENT

Vehicle design and mission concept, System engineering, Product assurance, Spacecraft integration and test, Spacecraft reliability and quality assurance, Small satellite engineering and application, Cost

TEXT BOOKS:

1. Fundamentals of Space Systems , V.L. Pisacane and R.C. Moore, AIAA Series, 2003
2. Spacecraft Systems Engineering , P. Fortescue, J. stark, and G. Swinerd, AIAA Series, 2005
3. Space Mission Analysis and design ,W.J. Larson and J. R. Wertz., AIAA Series, 1998
4. Rocket & Spacecraft Propulsion, (principles, practices and new developments), M.J.L Turner

VIBRATIONS AND STRUCTURAL DYNAMICS-ASPE-311

1. INTRODUCTION

Types of vibrations, S.H.M, principle of super position applied to Simple Harmonic Motions. Beats, Fourier theorem and simple problems.

2. UNDAMPED FREE VIBRATIONS

Single degree of freedom systems. Undamped free vibration,natural frequency of free vibration, Spring and Mass elements, effect of mass of spring, Compound Pendulum.

3. DAMPED FREE VIBRATIONS

Single degree of freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.

4. FORCED VIBRATION

Single degree of freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, reciprocating and rotating unbalance, vibration isolation, transmissibility ratio. due to harmonic exitation and support motion.

5. VIBRATION MEASURING INSTRUMENTS & WHIRLING OF SHAFTS

Vibrometer meter and accelerometer. Whirling of shafts with and without air damping. Discussion of speeds above and below critical speeds.

6. SYSTEMS WITH TWO DEGREES OF FREEDOM

Introduction, principle modes and Normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, Free vibration in terms of initial conditions. Geared systems. Forced Oscillations-Harmonic excitation. Applications:

a) Vehicle suspension.
b) Dynamic vibration absorber.
c) Dynamics of reciprocating Engines.

7. CONTINUOUS SYSTEMS

Introduction, vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler's equation for beams.

8. NUMERICAL METHODS FOR MULTI-DEGREE FREEDOM SYSTEMS

Introduction, Influence coefficients, Maxwell reciprocal theorem, Dunkerley's equation. Orthogonality of principal modes, Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle. Holzer's method, Stodola method.

TEXT BOOKS:

1. **Theory of Vibration with Applications**: W.T. Thomson and Marie Dillon Dahleh, Pearson Education 5th edition, 2007.
2. **Mechanical Vibrations**: V.P. Singh, Dhanpat Rai & Company Pvt. Ltd., 3rd edition, 2006

REFERENCE BOOKS:

1. **Mechanical Vibrations**: S.S. Rao, Pearson Education Inc, 4th Edition, 2003.
2. **Mechanical Vibrations**: S. Graham Kelly, Schaum's Outline Series, Tata McGraw Hill, Special Indian edition, 2007.

Theory & Practice of Mechanical vibrations: J.S. Rao & K. Gupta, New Age International Publications, New Delhi, 2001.

AEROSPACE STRUCTURES- II –ASPE-312

1. INTRODUCTION TO STRUCTURAL DESIGN

Structural layout of the Airplane and components, Structural design V-n diagram, loads acting on major components such as wing, fuselage, tails, landing gear etc., Concept of allowable stress and margin of safety.

2. UNSYMMETRICAL BENDING

Bending stresses in beams of unsymmetrical sections – Bending of symmetric sections with skew loads.

3. SHEAR FLOW IN OPEN SECTIONS

Thin walled beams, Concept of shear flow, shear centre, Elastic axis. With one axis of symmetry, with wall effective and ineffective in bending, unsymmetrical beam sections.

4. SHEAR FLOW IN CLOSED SECTIONS

Bredt – Batho formula, Single and multi – cell structures, Approximate methods, Shear flow in single & multi-cell structures under torsion. Shear flow in single and multi-cell under bending with walls effective and ineffective.

5. BUCKLING OF PLATES

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

6. STRESS ANALYSIS IN WING AND FUSELAGE: Procedure – Shear and bending moment distribution for semi cantilever and other types of wings and fuselage, thin webbed beam. With parallel and non parallel flanges, Shear resistant web beams, Tension field web beams (Wagner's).

7. DESIGN OF AEROSPACE STRUCTURES

Design criteria – Safety Factor – Design life criteria – Analysis method – Life Assessment procedures – Design Principle – Future Airworthiness Requirements – Two bay crack criteria – Widespread Fatigue damage.Case study of Aerospace Structural Design of Launch Vehicle

8. JOINTS AND FITTINGS AND INTRODUCTION TO POST BUCLKING

General theory for the design of fittings, Estimation of fitting design loads, design of riveted, bolted and welding joints, post buckling of structures, concept of effective width.

TEXT BOOKS:

1. **"Aircraft Structures for Engineering Students,** Megson, T.M.G.,, Edward Arnold, 1995.
2. **Aircraft Structures,** Peery, D.J., and Azar, J.J., 2nd edition, McGraw–Hill, N.Y., 1993.

REFEENCE BOOKS:

1. **"Analysis and Design of Flight vehicles Structures,** Bruhn. E.H., Tri – state off set company, USA, 1985.
2. **"Theory and Analysis of Flight Structures**, Rivello, R.M., McGraw-Hill, 1993.
3. **An Introduction to the Theory of Aircraft Structures**, D Williams & Edward Arnold.

FINITE ELEMENT METHODS - ASPE-313

1. INTRODUCTION: BASIC CONCEPTS, BACKGROUND REVIEW

Theory of Elasticity, Matrix displacement formulation, Energy concepts, Equilibrium and energy methods for analysing structures. Rayleigh - Ritz Method, Galerkin's Method, Simple applications in structural Analysis.

2. FUNDAMENTALS OF FINITE ELEMENT METHOD

Displacement function and natural coordinates, construction of displacement functions for 2 D truss and beam elements, applications of FEM for the analysis of truss, continuous beam and simple frame problems.

3. DISCRETE ELEMENTS

Bar elements, uniform Bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis, Frame element, Beam element, problems for various loadings and boundary conditions, Free vibration, longitudinal and lateral vibration, Use of local and natural coordinates.

4. CONTINUUM ELEMENTS

Plane stress, Plane strain and axisymmetric problems, constant and linear strain, triangular elements, stiffness matrix, axisymmetric load vector.

5. ANALYSIS OF 2 D CONTINUUM PROBLEMS

Elements and shape functions, Triangular, rectangular and quadrilateral elements, different types of elements, their characteristics and suitability for application, polynomial shape functions, Lagrange's and Hermitian polynomials, compatibility and convergence requirements of shape functions.

6. THEORY OF ISOPARAMETRIC ELEMENTS

Isoparametric, sub parametric and super-parametric elements, characteristics of Isoparametric quadrilateral, elements, structure of computer program for FEM analysis, description of different modules, pre and post processing.

7. FIELD PROBLEMS

Heat transfer problems, Steady' state fin problems, Derivation of element matrices for two dimensional problems, Torsion problems.

8. FINITE ELEMENT METHOD APPLICATIONS

Construction or discrete models - sub domains and nodes - simple elements for the FEM - Simplex, complex and multiples elements Polynomial selection - illustrative examples.

TEXT BOOKS:

1. **Finite Element analysis - Theory and Programming,** C.S. Krishnamurthy -, Tata McGraw Hill Co. Ltd, New Delhi.
2. Chandrupatla, T R and Belegundu, A.D - Introduction to Finite elements in Engineering", Printice Hall, Newyork, 2002.

REFERENCE BOOKS:

1. **Finite element analysis in engineering design,** Rajasekharan. S - Wheeler Publishers
2. **Finite Element Procedures,** Bathe. KJ , PHI Pvt. Ltd., New Delhi
3. **The Finite Element Method**, Zienkiewicz. O.C., Tata McGraw Hill Co. Ltd, New Delhi.

MODELING AND ANALYSIS LABORATORY –ASPE-314

LIST OF EXPERIMENTS

PART - A

1. Modeling of Symmetric Aerofoil geometry, and generation of body fitting mesh.
2. Modeling of Cambered Aerofoil geometry, and generation of body fitting mesh.
3. Modeling of 2-D Incompressible and Inviscid flow over an aerofoil. Computations and analysis for velocity vectors and pressures distributions.
4. Modeling of 2-D Incompressible and Viscous flow over an aerofoil. Computations and analysis for velocity vectors and pressures distributions.
5. Geometric modeling and mesh generation of 2-D Convergent-Divergent nozzle and analyses of flow for adiabatic conditions.

PART -B

1. Structural modeling of sandwich beam of rectangular cross-section and analyses for stresses.
2. Structural modeling of a three dimensional wing.
3. Structural modeling and stress analysis of a fuselage bulk head.
4. Structural modeling and stress analysis of a simply supported rectangular plate uniformly compressed in one direction.
5. Structural modeling and stress analysis of a simply supported rectangular plate uniformly compressed in one direction with a cut-out in center.

SIMULATION LABORATORY –ASPE-315

LIST OF EXPERIMENTS

PART - A

1. Falling sphere with viscous drag – Investigate velocity versus time plot; & simulate the fall.
2. Frequency response for a spring-mass system; simulation of the oscillations.
3. Simulation of simple servo-mechanism feedback system in time domain.
4. Simulation of simple servo-mechanism feedback system in `s` domain.
5. Simulate with transfer functions the experiments (3) and (4) above.

PART - B

1. Digital simulation of Analog Computations.
2. Simulate a bomb drop from an aircraft on a moving tank for pure –pursuit motion.
3. Simulate an Air Speed Indicator to read air speeds for the pressures read from a Pitot-static tube, with compressibility corrections.
4. Simulate a runaway.
5. Simulate a point take-off from a runaway

VII/VIII SEMESTER

AEROSPACE QUALITY ASSURANCE-ASPE-401

1. QUALITY CONCEPTS

Concepts and definition, design specifications, manufacture in conformance with design applications, role of quality assurance during usage of aircraft.

2. QUALITY ASSURANCE DURING OVERHAUL

Quality assurance during overall / repair of aircraft and its aggregates, concession and deviations . Production permits.

3. QUALITY CONTROL

Units of measure, measuring actual performance. Continuous process regulation. Strategic quality management. Role of quality director. Quality culture.

4. PROBABILITY CONCEPTS

Concept of variation. Quantitative methods of summarizing data. Normal curve, Exponential Probability distribution. Weibull probability distribution. Poisson distribution. Binomial distribution. Scope for data analysis. Sample size. Regression analysis.

5. DESIGNING FOR QUALITY

Early warning concepts and design assurance. Designing for basic function requirements. Design for Time- Oriented performance. Designing for safety. Designing for maintainability.

6. MANUFACTURE & RELIABILITY PREDICTION

Initial planning for qualities. Failure patterns. Predicting reliability during design. Exponential formula. Setting specification limits. Process quality audits. Self inspection.

7. INSPECTION, TEST & MEASUREMENTS

Sampling risk. Analysis of some rule to thumb. Sampling plot. Evaluation of parameters affecting field performance. Acceptance sampling plan. Feed back . Field data.

8. QUALITY AND AIRWORTHINESS ASSURANCE

Zero defect analogy, FMECA, Fault Tree Analysis, bench marking, quality circles, quality audit. Quality standards ISO 9000, TQM, CMM, Six Sigma. Quality organizational set up in production / repair / operational set up.

TEXT BOOK:

1. J M Juran, Frank M Gryna, `Quality Planning and Analysis,` TMH Publications, 2005

REFERENCE BOOKS:

1. M Fox, `Quality Assurance Management`, McGraw Hill Publications
2. Oalela, `ISO 9000 A, Manual for TQM`, Parga man Publishers.
3. S C Keshu and K K Ganapathi, `Aircraft production technology and Management,` Interline Publishers,1993

AEROELASTICITY –ASPE-402

1. INTRODUCTION

Aeroelasticity - definition and problems. Influence of aeroelastic phenomenon on design :- flutter, buffeting, dynamic loads problems, load distribution, divergence, control effectiveness & reversal. Critical flutter speeds versus wing sweep back. Effect of speed on control effectiveness.

2. DEFORMATION OF AIRPLANE STRUCTURES UNDER STATIC LOADS

Deformation due to several forces. Influence coefficients. Properties of influence coefficients. Deformation under distributed forces. Influence functions. Properties of influence functions. Simplified elastic airplane. Deformation of airplane wing. Force and torque applied to wing. Integration by weighting matrices. Bending, torsional and shear stiffness curves.

3. STATIC AEROELASTIC PHENOMENA

Load distribution and divergence-wing torsional divergence (two-dimensional case, & finite wing case). Swept wing divergence. Prevention of aeroelastic instabilities.

4. CONTROL EFFECTIVENESS AND REVERSAL

Aileron effectiveness and reversal -2 dimensional case, and finite wing case. Strip theory. Aileron effectiveness in terms of wing -tip helix angle. Critical aileron reversal speed. Rate of change of local pitching moment coefficient with aileron angle.

5. DEFORMATION OF AIRPLANE STRUCTURES UNDER DYNAMIC LOADS

Differential and Integral forms of equations of motions of vibrations. Natural modes and frequencies of complex airplane structures - introduction. Dynamic response phenomenon -equations of disturbed motion of an elastic airplane.

6. DYNAMIC PROBLEMS OF AEROELASTICITY

Flutter. Single-degree-of- freedom system. Determination of critical flutter speed. Aeroelastic modes. Wing bending and torsion flutter. Coupling of bending and torsion oscillations and destabilizing effects of geometric incidences. Stall flutter, Supersonic panel flutter, Buffeting and, Aileron buzz. Flutter prevention and control.

7. TEST MODEL SIMILARITES

Dimensional concepts. Vibration model similarity laws. Dimensionless form of equation of motion. Mode shapes and natural frequencies in dimensionless forms. Model scale factors. Flutter model similarity law. Scale factors. Structural simulation:-shape, mass and stiffness.

8. TESTING TECHNIQUES

Measurement of structural flexibility. Measurements of natural frequencies and mode shapes. Polar plot of the damped response. Identification and measurement of normal modes. Steady state aeroelastic model testing. Dynamic aeroelastic model testing. Flight flutter testing.

TEXT BOOKS:

1. Dowell, E. H., Crawley, E. F., Curtiss Jr., H. C., Peters, D. A., Scanlan, R. H., and Sisto, F., A Modern Course in Aeroelasticity, Kluwer Academic Publishers, 3rd Edition, 1995. (TL574.A37.M62)
2. Bisplinghoff, R., Ashley, H., and Halfman, R. L., Aeroelasticity, Dover, 1955. (TL570.B622)

REFERENCE BOOKS:

1. Fung, Y. C., An Introduction to the Theory of Aeroelasticity, 1955 (Dover, 1969).
2. Megson THG, `Aircraft structures for Engineering students`, Edward Arnold.
3. Bisplinghoff, R. and Ashley, H., Principles of Aeroelasticity, Dover, 1962. (TL570.B623)

SPACE MECHANICS AND LAUNCH VEHICALS-ASPE-403

1. INTODUCTION TO SPACE MECHANICS

Space vehicles/ platforms. Inertial and Earth fixed coordinate reference frames. Representation of vector (position, velocity and acceleration) in fixed and moving reference frames, Coordinate transformations, Euler transformations.

2. CENTRAL FORCE MOTION

Two body problem and one body problem. Kepler's laws of motion.

3. ORBITAL MECHANICS

Establishment of orbits, single impulse and two impulse orbital transfers, ballistic trajectory, orbital perturbations – general and special perturbation methods, Sun synchronous and Geo-synchronous orbits.

4. SATELLITE DYNAMICS

Geosynchronous and geostationary satellites life time - satellite perturbations - Hohmann orbits - calculation of orbit parameters - Determination of satellite rectangular coordinates from orbital elements

5. INTRODUCTION TO LAUNCH VEHICLES

Introduction to launch vehicles.. Introduction to Solid, Liquid and Cryogenic rocket engines. Performance parameters. Comparison of liquid propellant, solid Propellant and hybrid rockets.

6. PRINCIPLES OF OPERATION AND TYPES OF ROCKET ENGINES

One dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields. Description of vertical, inclined and gravity turn trajectories. Simple approximations to burnout velocity –

7. ROCKET PERFORMANCE AND STAGING

Launch vehicle trajectories, two body problem and orbital elements. Staging of rockets

8. SPACECRAFT

Preliminary concepts of space, spacecraft. Introduction to manned and unmanned space missions. Spacecraft power generation. Life support system for manned space missions.

Materials for spacecraft. Selections of materials for spacecraft - special requirements of materials to perform under adverse conditions - ablative materials. . Life time estimation for a satellite.

TEXT BOOKS:

1. M. H. Kaplan: Modern Spacecraft Dynamics and Control, John Wiley and Sons, 1976.
2. W. T. Thomson: Introduction to Space Dynamics, Dover Publications, 1986
3. G P Sutton, Rocket Propulsion Elements John Wiley and Sons, 1993

REFERENCE BOOK:

1. H. S. Siefert (Ed.), "Space Mechanics", John Wiley & Sons, 1969.

AVIONICS-ASPE-404

1. POWER DISTRIBUTION SYTEM

Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilisation-typical application to avionics. Need for Avionics in civil and military aircraft.

2. INERTIAL NAVIGATION SYSTEM

Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing.

3. ELECTRONIC FLIGHT CONTROL SYSTEM

Fly-by-wire system: - basic concept and features. Pitch and Roll rate: - command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.

4. ELECTRONIC FLIGHT INSTRUMENT SYSTEMS

Display -units, presentation, failure, and annunciation. Display of air data.

5. INTRODUCTION TO AVIONICS SUB SYSTEMS AND ELECTRONIC CIRCUITS

Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.

6. PRINCIPLES OF DIGITAL SYSTEMS

Digital Computers – Microprocessors – Memories

7. FLIGHT DECK AND COCKPITS

Control and display technologies CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) - Civil cockpit and military cockpit : MFDS, HUD, MFK, HOTAS

8. AVIONICS SYSTEMS INTEGRATION

Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar , Electronic Warfare, and fire control system. Avionics system architecture–Data buses MIL–STD 1553 B.

TEXT BOOKS:

1. R P G Collinson, `Introduction to Avionics Systems,` Kulwar Academic Publishers`, 2003
2. E H J Pallett, `Aircraft Electrical System,`. Pitman Publishers, 1976.

REFERENCE BOOKS:

1. Middleton, D.H., Ed., `Avionics Systems`, Longman Scientific and Technical Longman Group UK Ltd., England, 1989.
2. Spitzer, C.R., `Digital Avionic Systems`, Prentice Hall, Englewood Cliffs, N.J., USA, 1987.
3. R.B. Underdown & Tony Palmer, `Navigation~, Black Well Publishing 2001.

FLIGHT DYNAMICS LAB -ASPE-405

LIST OF EXPERIMENTS

1. Introduction to flight testing,
2. Instrumentation, techniques and data reduction methods,
3. Calibration of flight and special flight test instruments.
4. Evaluation of glider drag polar.
5. Evaluation of cruise and climb performance of a small airplane.
6. Determination of static and maneuvre stability and control characteristics.
7. Observations of airplane dynamic modes and stall characteristics.
8. Introduction to GPS based navigation.
9. Introduction to auto-pilot.

STRUCTURES LABORATORY-ASPE-406

LIST OF EXPERIMENTS

1. Deflection of a Simply Supported Beam.S
2. Verification of Maxwell's Reciprocal Theorem.
3. Determination of Young’s Modulus using strain gages.
4. Poisson Ratio Determination.
5. Buckling Load of Slender Eccentric Columns and Construction of Southwell Plot
6. Shear failure of Bolted and Riveted Joints.
7. Bending Modulus of a Sandwich Beam
8. Verification of the Superposition Theorem

PROJECT- ASPE-407

Students have to submit a project model and fabrication work along with the project report containing all the details about the project. Project should be related to the courses taught or his/her own idea in the concerned area.

GUIDANCE AND NAVIGATION-ASPE-408

1. INTRODUCTION

Concepts of navigation, guidance and control. Introduction to basic principles. Air data information.

2. RADAR SYSTEMS

Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI)

3. TRACKING WITH RADAR

Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT)

4. OTHER GUIDANCE SYSTEMS

Gyros and stabilised platforms.Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. Satellite navigation. GPS.

5. TRANSFER FUNCTIONS

Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop.

6. MISSILE CONTROL SYSTEM

Guided missile concept. Roll stabilisation. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus.

7. MISSILE GUIDANCE

Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance

8. INTEGRATED FLIGHT/FIRE CONTROL SYSTEM

Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle, Auto Pilot

TEXT BOOKS:

1. Merrilh I. Skolnik,` Introduction to Radar Systems`, 3rd edition, Tata Mc Graw Hill , 2001.
2. John H Blakelock,` Automatic control of Aircraft & Missiles`, Wile –Inter Science Publication, 2nd edition, May 1990.

REFERENCE BOOK:

1. R.B. Underdown & Tony Palmer, `Navigation`, Black Well Publishing; 2001

THEORY OF PLATES AND SHELLS-ASPE-409

1. INTRODUCTION

Plate and Shell Structures in Aerospace Vehicles. Flexural rigidity of plates. Flexural rigidity of shells. Introduction to bending and buckling of plates and shells. Reinforced plates. Eccentrically compressed shells.

2. BENDING OF THIN PLATES –STRESSES

Pure bending of plates. Isotropic and orthotropic flat plates. Flexural rigidity of plate. Bending of plates by distributed lateral load. Combined bending and tension or compression. Bending and twisting moments. Shear stress.

3. BENDING OF THIN PLATES - STRAIN ENERGY

Slopes of deflection of surface. Different edge conditions: - built in edge, simply supported edge and, free edge. Combined bending and tension or compression of plates. Strain energy by: – bending of plates, bending by lateral loads, combined bending and tension or compression of plates.

4. BUCKLING OF THIN PLATES

Method of calculation of critical loads. Buckling of simply supported rectangular plates uniformly compressed in one direction. Buckling of uniformly compressed rectangular plates simply supported along two opposite sides perpendicular to the direction of compression and having various edge conditions along the other two sides. Critical values of compressive stress.

5. BUCKLING OF REINFORCED PLATES

Stability of plates reinforced by ribs. Simply supported rectangular plates with longitudinal ribs. General equation for critical compressive stress. Critical compressive stress for a plate stiffened by one rib. Study of the experimental value of buckling of plates.

6. BENDING OF THIN SHELLS

Deformation of an element of a shell. Expression for components of normal stresses. Flexural rigidity of shell. Case of deformation with presence of shearing stresses.

7. STRAIN ENERGY OF DEFORMATION OF SHELLS

Strain energy of deformation of shell:-bending and stretching of middle surface. Symmetrical deformation of a circular cylindrical shell. Differential equation for bending of strip.

8. BUCKLING OF SHELLS

Symmetrical buckling of cylindrical shell under the action of uniform axial compression :-differential equation , critical stress. Symmetrical buckling of cylindrical shell under the action of uniform axial pressure. Study of the experimental values of cylindrical shells in axial compression. Bent or eccentrically compressed shells.

TEXT BOOKS:

1. Timoshenko, S.P. and Gere, J.M., “Theory of Elastic Stability”, McGraw-Hill Book Co. 1986.
2. Timoshenko, S.P. Winowsky. S., and Kreger, “Theory of Plates and Shells”, McGraw-Hill Book Co. 1990.

REFERENCE BOOK:

1. Flugge, W. “Stresses in Shells”, Springer – Verlag, 1985.

APPLIED GAS DYNAMICS-ASPE-410

1. ONE DIMENSIONAL COMPRESSIBLE FLOW

Basic equations of compressible flow. Steady one-dimensional flow. Discharge from reservoir. De Laval Nozzle. Flow through converging, diverging passages; Performance under various back pressures. Diffusers. Dynamic head measurements in compressible flow.

2. NORMAL, OBLIQUE SHOCKS AND EXPANSION WAVES

Governing Equations of Normal Shock Wave. Prandtl relation and Rankine - Hugoniot equation. Oblique shocks and corresponding relations. Shock polar & Hodograph plane. Supersonic flow over a wedge. Supersonic compression and supersonic expansion. Detached shocks. Mach reflection. Intersection of waves of same and opposite families. Introduction to the Method of Characteristic.

3. FANNO FLOW

Flow with friction in constant area duct. Fanno lines. Fanno equation.
Definition of friction constant, Friction loss. Effect of wall friction on flow properties. Friction parameter. Local flow properties in terms of local Mach number.

4. RAYLEIGH FLOW

Flow with heating or cooling in ducts. Governing equations. Heating relations for a perfect gas. Slope of Rayleigh line. Entropy considerations. Maximum heat transfer.

5. DIFFERENTIAL EQUATIONS OF MOTION FOR STEADY COMPRESSIBLE FLOWS

Basic potential equations for compressible flow. Linearisation of potential equation- small perturbation theory. Methods for solution of nonlinear potential equation -Introduction. Boundary conditions. Pressure coefficient expression.

6. SIMILARITY RULES

Two-dimensional flow. Prandtl - Glauert rule for subsonic and supersonic flow. Von-Karman rule for transonic flow. Gothert rules. Application to wings of finite span. Aerodynamic characteristics for actual and transformed bodies. Effect of thickness and camber. Lift and drag divergence. Shock induced flow separation. Prandtl – Meyer expansion fan. Lift, drag, pitching moment and center of pressure of supersonic profiles.

7. FLOW OF REAL FLUIDS

Shock Wave – Boundary layer interaction. Experimental characteristics of airfoils in compressible flow. Nature of pressure distribution.

8. MEASUREMENTS IN COMPRESSIBLE FLOW

High Speed Wind tunnels : In-draft, Induction, Continuous and Shock tubes. Optical methods of flow visualization. Wind tunnel Instrumentation and measurements.

TEXT BOOKS:

1. Rathakrishnan, E., “Gas Dynamics”, Prentice Hall of India.1995 edition.
2. Yahya, S.M., “Fundamentals of Compressible flow”, Wiley Eastern, 2003.

REFERENCE BOOK:

1. John D Anderson, “Modern Compressible Flow”, Mc Graw Hill 1999.