NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

NOORUL ISLAM UNIVERSITY, KUMARACOIL

M.E. AERONAUTICAL ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER – I

SL. NO.	SUBJECT CODE	SUBJECT	L	T	P	C
Theory						
1.	MA1503	Applied Mathematics	3	1	0	4
2.	AE1501	Aerodynamics	3	0	0	3
3.	AE1502	Aircraft Structures	3	0	0	3
4.	AE1503	Propulsion	3	0	0	3
5.	AE1504	Vibration and Aero Elasticity	3	0	0	3
6.	XX5E1	Elective I	3	0	0	3
Practical						
7.	AE1571	Structures Laboratory	0	1	2	2
Total			18	2	2	21

MA1503 APPLIED MATHEMATICS

L	T	P	C
3	1	0	4

AIM:

To equip the students of Engineering, the knowledge of Mathematics and its applications so as to enable them to apply them for the branch in which they are admitted.

OBJECTIVE:

To impart the basic knowledge about Matrices, Transforms, Conformal Mappings and Numerical problems so that those concepts could be adopted in their concerned branch.

UNIT I ADVANCED MATRIX THEORY 9

Generalised Eigen vectors– Jordan canonical form — Matrix norms – Singular value decomposition – Pseudo inverse – Least square approximations – QR decomposition.

UNIT II CALCULUS OF VARIATIONS 9

Euler's equation – Functional dependent on first and higher order derivatives – Functional dependent on functions of several independent variables —Isoperimetric Problems.

UNIT III SIMULATION

Discrete Event Simulation – Stochastic Simulation - Monte Carlo Simulation – Generation of Random Numbers using Congruent method – Applications to Queueing systems.

UNIT IV CONFORMAL MAPPING AND ELLIPTIC INTEGRAL 9

Schwarz – Christoffel Transformation – Transformation of boundaries in parametric form – Physical applications – Application to Fluid flow.

UNIT V FIRST AND SECOND ORDER ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS 9

Solution of first order differential equations -Single step Methods: Taylor's Series, Fourth order Runge-Kutta method. Finite difference solution of one dimensional heat equation: Bender Schmidt Method– One dimensional wave equation and two dimensional Poisson equations.

L: 45 + T: 15, TOTAL: 60 PERIODS

REFERENCES:

1. Bronson, R., "Matrix Operations", Schaum's Outline Series, McGraw–Hill, New York
2. Spiegel, M.R.," Theory and Problems of complex variables with an introduction to conformal mapping and its applications. Schaum's outline series" McGraw-Hill Book Co.
3. Gupta, A.S., "Calculus of Variations with Applications", Prentice-Hall of India,

New Delhi.
4. Dr.Venkataraman, M.K., " Higher Mathematics for Engineering and Science", National Publishing Company.
5. Philips and Raveendran " Operations Research- Principles and Practice"
6. Jain M.K., Iyengar. S.R.K and Jain. R.K, "Numerical method for scientific and Engineering Computations", New Age International(P) Ltd., Publishers, 2003.
7. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition, Khanna Publishers, Delhi 2007.

AE1501 AERODYNAMICS L T P C
3 0 0 3

OBJECTIVE

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

UNIT I INTRODUCTION TO AERODYNAMICS 9

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

UNIT II INCOMPRESSIBLE FLOW THEORY 9

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

UNIT III COMPRESSIBLE FLOW THEORY 9

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

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 9

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

UNIT V VISCOUS FLOW AND FLOW MEASUREMENTS 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE1502 AIRCRAFT STRUCTURES L T P C
3 0 0 3

OBJECTIVE

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

UNIT I BENDING OF BEAMS 9

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

UNIT II SHEAR FLOW IN OPEN SECTIONS 9

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

UNIT III SHEAR FLOW IN CLOSED SECTIONS 9

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

UNIT IV STABILITY PROBLEMS 9

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

UNIT V ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE1503 PROPULSION L T P C
3 0 0 3

OBJECTIVE

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

UNIT I ELEMENTS OF AIRCRAFT PROPULSION 9

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

UNIT II PROPELLER THEORY 9

Propeller Power losses, propeller performance, incompressible theory for positive thrust, incompressible theory for negative thrust, prediction of static thrust, prediction of in-flight thrust, propeller thrust control, propeller noise control, propeller chart, propeller in-flight prediction of thrust.

UNIT III INLETS, NOZZLES AND COMBUSTION CHAMBERS 9

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

UNIT IV COMPRESSORS AND TURBINES 9

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

UNIT V ROCKET PROPULSION 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE1504 VIBRATIONS AND AERO ELASTICITY

L T P C
3 0 0 3

UNIT I: SINGLE DEGREE OF FREEDOM SYSTEMS 10

Introduction to simple harmonic motion, D'Alembert's Principle, Free vibrations – Damped vibrations – Forced Vibrations, with and without damping – support excitation – Vibration measuring instruments.

UNIT II: MULTI DEGREES OF FREEDOM SYSTEMS 10

Two degrees of freedom systems - Static and Dynamic couplings – vibration absorber- Principal co-ordinates - Principal modes and orthogonal condition – Eigen value problems - Hamilton's principle - Lagrangean equations and application.

UNIT III: CONTINUOUS SYSTEMS & APPROXIMATE METHODS 9

Vibration of elastic bodies - Vibration of strings - Longitudinal - Lateral and Torsional Vibration, Approximate methods - Rayleigh's method - Dunkerlay's method – Rayleigh-Ritz method, Matrix Iteration method.

UNITIV: ELEMENTS OF AEROELASTICITY **8**

Vibration due to coupling of bending and torsion - Aeroelastic problems – Collars triangle - Wing Divergence - Aileron Control reversal – Flutter – Buffeting.

UNIT V :EXAMPLES OF AEROELASTIC PROBLEMS **8**

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

TOTAL: 45 PERIODS

TEXT BOOKS

1.Thomson W T, 'Theory of Vibration with Application' - CBS Publishers, 1990.
2.G.K.Grover, "Mechanical Vibrations", 7th Edition, Nem Chand Brothers, Roorkee, India, 2003.

REFERENCES

1. Timoshenko S., Vibration Problems in Engineering – John Wiley and Sons, New York, 1993.
2. Bisplinghoff R.L., Ashely H and Hogman R.L., Aeroelasticity – Addision Wesley Publication, New york, 1983.
3. William W Seto, 'Mechanical Vibrations' – McGraw Hill, Schaum Series.
4. TSE. F.S., Morse, I.F., Hunkle, R.T., Mechanical Vibrations – Prentice Hall, New York, 1984.
5. Leonard Meirovitch, 'Elements of Vibration Analysis' – McGraw Hill International Edition Clarence W DeSilva, `Vibration – Fundamentals and Practice', CRC Press, Special Indian Edition, 2005.

AE1571	**STRUCTURES LABORATORY**	**L**	**T**	**P**	**C**
		0	**1**	**2**	**2**

OBJECTIVE

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

LIST OF EXPERIMENTS

1. Constant strength Beams
2. Buckling of columns
3. Unsymmetrical Bending of Beams
4. Shear Centre Location for Open Section
5. Shear Centre Location for Closed Section
6. Flexibility Matrix for Cantilever Beam
7. Combined Loading

8. Calibration of Photo Elastic Materials
9. Stresses in Circular Disc Under Diametrical Compression – Photo Elastic Method
10. Vibration of Beams with Different Support Conditions
11. Determination of elastic constants of a composite laminate.
12. Wagner beam

TOTAL: 45 PERIODS

LABORATORY EQUIPMENTS REQUIREMENTS

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

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SEMESTER – II

SL. NO.	SUBJECT CODE	SUBJECT	L	T	P	C
Theory						
1.	AE1505	Flight Dynamics	3	0	0	3
2.	AE1506	Finite Element Methods	3	0	0	3
3.	AE1507	Computational Fluid Dynamics	3	0	0	3
4.	AE1508	Numerical Heat Transfe**r**	3	0	0	3
5.	AE1509	Wind Tunnel Techniques	3	0	0	3
6.	XX15E2	Elective II	3	0	0	3
Practical						
7.	AE1572	CFD Lab	0	1	2	2
Total			18	1	2	20

AE1505 FLIGHT MECHANICS L T P C

3 0 0 3

OBJECTIVE

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

UNIT I PRINCIPLES OF FLIGHT 7

Physical properties and structure of the atmosphere, International Standard Atmosphere, Temperature, pressure and altitude relationship, Measurement of speed – True, Indicated and Equivalent air speed, Streamlined and bluff bodies, Various Types of drag in airplanes, Drag polar, Methods of drag reduction of airplanes.

UNIT II AIRCRAFT PERFORMANCE IN LEVEL, CLIMBING AND GLIDING FLIGHT 11

Straight and level flight, Thrust required and available, Power required and available, Effect of altitude on thrust and power, Conditions for minimum drag and minimum power required, Gliding and Climbing flight, Range and Endurance

UNIT III ACCELERATING FLIGHT 8

Take off and landing performance, Turning performance, horizontal and vertical turn, Pull up and pull down, maximum turn rate, V-n diagram

UNIT IV LONGITUDINAL STABILITY AND CONTROL 10

Degrees of freedom of a system, static and dynamic stability, static longitudinal stability, Contribution of individual components, neutral point, static margin, Hinge moment, Elevator control effectiveness, Power effects, elevator angle to trim, elevator angle per g, maneuver point, stick force gradient, aerodynamic balancing, Aircraft equations of motion, stability derivatives, stability quartic, Phugoid motion

UNIT V LATERAL, DIRECTIONAL STABILITY AND CONTROL 9

Yaw and side slip, Dihedral effect, contribution of various components, lateral control, aileron control power, strip theory, aileron reversal, weather cock stability, directional control, rudder requirements, dorsal fin, One engine inoperative condition, Dutch roll, spiral and directional divergence, autorotation and spin

TOTAL: 45 PERIODS

TEXT BOOKS

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.

REFERENCES

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

2. Clancey,L.J. Aerodynamics, Pitman, 1986.
3. Babister, A.W. Aircraft stability and response, Pergamon Press, 1980.
4. Nelson, R.C. Flight Stability & Automatic Control, McGraw-Hill, 1989.
5. McCormic, B.W., Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.

AE1506 FINITE ELEMENT METHODS L T P C
3 0 0 3

OBJECTIVE

To introduce the concept of numerical analysis of structural components

UNIT I INTRODUCTION 7

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 11

Use of bar and beam elements for static, dynamic and structural analysis – Bar of varying section – Temperature effects

Practical

Program Development and use of software package for application of bar and beam elements for static, dynamic and stability analysis.

UNIT III CONTINUUM ELEMENTS 11

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

Practical

Solution for 2-D problems (static analysis and heat transfer) using software packages.

UNIT IV ISOPARAMETRIC ELEMENTS 11

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

Practical

Solution for 2-D problems (static analysis and heat transfer) using software packages.

UNIT V SOLUTION SCHEMES 5

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

TOTAL: 45 PERIODS

TEXT BOOKS

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, Prentice Hall, 2002
3. S.S.Rao, "Finite Element Method in Engineering", Butterworth, Heinemann Publishing, 3rd Edition, 1998

REFERENCES

1. 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.
2. K.J. Bathe and E.L. Wilson, "Numerical Methods in Finite Elements Analysis", Prentice Hall of India Ltd., 1983.
3. C.S. Krishnamurthy, "Finite Elements Analysis", Tata McGraw-Hill, 1987.

AE1507 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

OBJECTIVE

To study the flow of dynamic fluids by computational methods

UNIT I NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS 9

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.

Practical

Numerical solution for CD nozzle isentropic flows and local similar solutions of boundary layer equations.

UNIT II GRID GENERATION 9

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries.

Practical

Elliptic grid generation using Laplace's equations for geometries like airfoil and CD nozzle.

UNIT III TRANSONIC RELAXATION TECHNIQUES 9

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.

Practical

Numerical solution of 1-D conduction- convection energy equation using time dependent methods using both implicit and explicit schemes – application of time split method for the above equation and comparison of the results.

UNIT IV TIME DEPENDENT METHODS 9

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

Practical

Numerical solution of unsteady 2-D heat conduction problems using SLOR methods

UNIT V PANEL METHODS 9

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

Practical

Numerical solution of flow over a cylinder using 2-D panel methods using both vertex and source panel methods for lifting and non lifting cases respectively.

TOTAL: 45 PERIODS

TEXT BOOKS

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.

REFERENCES

1. T.K.Bose, "Computation Fluid Dynamics" Wiley Eastern Ltd., 1988.
2. H.J. Wirz and J.J. Smeldern "Numerical Methods in Fluid Dynamics", McGraw-Hill & Co., 1978.
3. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York, 1995.

AE1508 NUMERICAL HEAT TRANSFER 3 0 0 3

OBJECTIVE

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

UNIT I BASICS OF HEAT TRANSFER 9

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

UNIT II CONDUCTIVE HEAT TRANSFER 9

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

UNIT III CONVECTIVE HEAT TRANSFER

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

UNIT IV RADIATIVE HEAT TRANSFER 9

Radiation-Stefan Boltzmann law-Shape factor-Numerical treatment of radiation problems- transient mixed convection and radiation from a vertical fin-Radiation with shield.

UNIT V SPECIAL PROBLEMS IN AEROSPACE ENGINEERING 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE1509 WIND TUNNEL TECHNIQUES L T P C

3 0 0 3

UNIT I PRINCIPLES OF MODEL TESTING: 9

Buckingham Theorem – Non dimensional numbers – Scale effect – Geometric Kinematics and Dynamic similarities.

UNIT II WIND TUNNELS: 9

Classification – special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions – Layouts – sizing and design parameters.

UNIT III CALIBRATION OF WIND TUNNELS: 9

Test section speed – Horizontal buoyancy – Flow angularities – Turbulence measurements – Associated instrumentation – Calibration of supersonic tunnels.

UNIT IV WIND TUNNEL MEASUREMENTS: 9

Steady and Unsteady Pressure and Velocity measurements – Force measurements – Three component and six component balances – Internal balances – Principles of Hotwire Anemometer.

UNIT V FLOW VISUALIZATION: 9

Smoke and Tuft techniques – Dye injection special techniques – Optical methods of flow visualization- Schiliren Method, Mach-Zehndar Interferometer, Shadowgraph.

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE1572 CFD LABORATORY L T P C

0 1 2 2

OBJECTIVE

To familiarize the students in the basic concepts of CFD and usage of software.

LIST OF EXPERIMENTS

1. Isentropic flow through a conical convergent divergent nozzle
2. Flow over a sphere at low Reynolds number
3. Flow over a sphere at high Reynolds number
4. Flow over a standard NACCA aerofoil at different mach numbers (0 to 5)
5. Flow over a standard NACCA aerofoil at different angle of attack
6. Flow through a subsonic diffuser-ejector
7. Flow through a air-intake
8. Flow through a supersonic ejector-diffuser
9. Flow over a multi-element aerofoil

TOTAL: 45 PERIODS

LABORATORY EQUIPMENTS REQUIREMENTS

Sl.No.	Name of the Equipment	Quantity
1	Computer nodes	30
2	Gambit	30 licenses
3	ANSYS, Fluent	30 licenses
4	UPS	1

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SEMESTER – III

SL. NO.	SUBJECT CODE	SUBJECT	L	T	P	C
THEORY						
1.	XX15E3	Elective III	3	0	0	3
2.	XX15E4	Elective IV	3	0	0	3
3.	XX15E5	Elective V	3	0	0	3
PRACTICAL						
4.	AE1573	Propulsion Laboratory	0	1	2	2
5.	AE15P1	Project work Phase I	0	0	12	6
Total			9	1	14	17

AE1573 PROPULSION LABORATORY L T P C

0 1 2 2

OBJECTIVE

To understand the basic concepts and carryout experiments in Aerospace Propulsion.

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. Study of free convective heat transfer over a flat plate
5. Cascade testing of a model of axial compressor blade row.
6. Study of performance of a propeller.
7. Determination of heat of combustion of aviation fuel.
8. Combustion performance studies in a jet engine combustion chamber.
9. Study of free jet.
10. Study of wall jet.

TOTAL: 45 PERIODS

LIST OF EQUIPMENTS

(for a batch of 30 students)

Sl.No	Equipments	Qty	Experiments No.
1	Piston engines	2	1
2	Jet Engine /Engine model	1	2
3	Forced Convective apparatus	1	3
4	Free Convective apparatus	1	4
5	Axial compressor blade row model with pressure tapping	1	5
6	Watertube manometers (20 tubes)	2	5,8,9
7	Subsonic wind tunnel	1	4
8	Propeller model static and total pressure probes	4	8,9

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SEMESTER – IV

SL. NO.	SUBJECT CODE	SUBJECT	L	T	P	C
1.	AE15P5	Project work Phase II	0	0	36	18
Total			0	0	36	18

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LIST OF ELECTIVES

Sl. No.	Code	Subject Title	L	T	P	C
1.	AE15A1	Experimental Stress Analysis	3	0	0	3
2.	AE15A2	Boundary Layer Theory	3	0	0	3
3.	AE15A3	Aircraft Design	3	0	0	3
4.	AE15A4	Industrial Aerodynamics	3	0	0	3
5.	AE15A5	Helicopter Aerodynamics	3	0	0	3
6.	AE15A6	Theory of Plates and Shells	3	0	0	3
7.	AE15A7	Structural Dynamics	3	0	0	3
8.	AE15A8	Aero elasticity	3	0	0	3
9.	AE15A9	High Temperature Problems in Structures	3	0	0	3
10.	AE15B1	Fatigue and Fracture Mechanics	3	0	0	3
11.	AE15B2	Theory of Elasticity	3	0	0	3
12.	AE15B3	Hypersonic Aerodynamics	3	0	0	3
13.	AE15B4	High Temperature Gas Dynamics	3	0	0	3
14.	AE15B5	Advanced Propulsion Systems	3	0	0	3
15.	AE15B6	Experimental Methods in Fluid Mechanics	3	0	0	3
16.	AE15B7	Space Mechanics	3	0	0	3
17.	AE15B8	Cryogenics	3	0	0	3
18.	AE15B9	Wind Engineering	3	0	0	3
19.	AE15C1	Combustion Engineering	3	0	0	3
20.	AE15C2	Avionics	3	0	0	3
21.	AE15C3	Control & Guidance	3	0	0	3

AE15A1 EXPERIMENTAL STRESS ANALYSIS L T P C

3 0 0 3

OBJECTIVE

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

UNIT I INTRODUCTION 8

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

UNIT II ELECTRICAL RESISTANCE STRAIN GAUGES 12

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

UNIT III PRINCIPLES OF PHOTOELASTICITY 9

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

UNIT IV PHOTOELASTICITY AND INTERFEROMETRY TECHNIQUES 9

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

UNIT V NON DESTRUCTIVE TECHNIQUES 7

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A2 BOUNDARY LAYER THEORY L T P C
3 0 0 3

UNIT I VISCOUS FLOW EQUATIONS 9

Fundamental equations of Viscous flow-Newton’s law of viscosity-Navier-Stokes Equations, Creeping motion, Couette flow, Poiseuille flow through ducts, Ekman drift.

UNIT II LAMINAR BOUNDARY LAYER 9

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

UNIT III TURBULENT BOUNDARY LAYER 9

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

UNIT IV APPROXIMATE SOLUTION TO BOUNDARY LAYER EQUATIONS 9

Approximate integral methods, digital computer solutions – Von Karman – Polhausen method-Discretization of partial differential equations

UNIT V THERMAL BOUNDARY LAYER 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A3 **AIRCRAFT DESIGN** **L T P C**
3 0 0 3

OBJECTIVE

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

UNIT I REVIEW OF DEVELOPMENTS IN AVIATION 9

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

UNIT II POWER PLANT TYPES AND CHARACTERISTICS 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.

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A4 INDUSTRIAL AERODYNAMICS L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I ATMOSPHERE 9

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

UNIT II WIND ENERGY COLLECTORS 9

Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory.

UNIT III VEHICLE AERODYNAMICS 9

Power requirements and drag coefficients of automobiles, Effects of cut back angle, Aerodynamics of trains and Hovercraft.

UNIT IV BUILDING AERODYNAMICS 9

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

UNIT V FLOW INDUCED VIBRATIONS 9

Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall flutter.

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A5 HELICOPTER AERODYNAMICS L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I INTRODUCTION 7

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

UNIT II HELICOPTER AERODYNAMICS 12

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

UNIT III PERFORMANCE 9

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

UNIT IV STABILITY AND CONTROL 9

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

UNIT V AERODYNAMIC DESIGN 8

Momentum and simple blade element theories- Figure of merit -Blade section design, Blade tip shapes, Types of Drag - Drag estimation – Rear fuselage upsweep.

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A6 THEORY OF PLATES AND SHELLS L T P C

3 0 0 3

OBJECTIVE:

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

UNIT I CLASSICAL PLATE THEORY 8

Introduction to Classical Plate Theory – Concept- Assumptions – Governing Differential Equations – Primary and Secondary Boundary Conditions.

UNIT II PLATES OF VARIOUS SHAPES 10

Navier's Method of Solution for Simply Supported Rectangular Plates – Levy's Method of Solution for Rectangular Plates under Different Boundary Conditions – Circular plates.

UNIT III EIGEN VALUE ANALYSIS 8

Stability and Free Vibration Analysis of for Rectangular Plates- Simply supported plates- Cantiliver plates- Circular plates- Analysis under different boundary conditions.

UNIT IV APPROXIMATE METHODS 10

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

UNIT V SHELLS 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A7 STRUCTURAL DYNAMICS L T P C

3 0 0 3

UNIT I FORCE-DEFLECTION PROPERTIES OF STRUCTURES 10

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

UNIT II PRINCIPLES OF DYNAMICS 10

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

UNIT III NATURAL MODES OF VIBRATION 10

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

UNIT IV ENERGY METHODS 8

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

UNIT V APPROXIMATE METHODS 7

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A8 AEROELASTICITY L T P C

3 0 0 3

OBJECTIVE

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

UNIT I AEROELASTIC PHENOMENA 6

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

UNIT II DIVERGENCE OF A LIFTING SURFACE 10

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

UNIT III STEADY STATE AEROLASTIC PROBLEMS 9

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

UNIT IV FLUTTER PHENOMENON 14

Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasisteady aerodynamic derivatives. Galerkin method for critical

flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter prevention and control.

UNIT V EXAMPLES OF AEROELASTIC PROBLEMS 6

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15A9 HIGH TEMPERATURE PROBLEMS IN STRUCTURES L T P C
3 0 0 3

UNIT I TEMPERATURE EQUATIONS & AERODYNAMIC HEATING 9

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

UNIT II THERMAL STRESS ANALYSIS 9

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

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

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

UNIT IV THERMAL STRESSES IN PLATES 9

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

UNIT V SPECIAL TOPICS & MATERIALS 9

Thermal bucking, Fatigue and shock applications – High temperature effects on material properties- Intermetallics, high temperature ceramics- Iron base, Nickel base and Cobalt base super alloys.

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCE

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

AE15B1 FATIGUE AND FRACTURE MECHANICS L T P C
3 0 0 3

UNIT I FATIGUE OF STRUCTURES 10

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

UNIT II STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR 8

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

UNIT III PHYSICAL ASPECTS OF FATIGUE 5

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

UNIT IV FRACTURE MECHANICS 15

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

UNIT V FATIGUE DESIGN AND TESTING 7

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15B2 THEORY OF ELASTICITY L T P C
3 0 0 3

OBJECTIVE

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

UNIT I INTRODUCTION 6

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

UNIT II BASIC EQUATIONS OF ELASTICITY 10

Equations of equilibrium – Compatibility equations in strains and stresses –Boundary Conditions - Saint-Venant's principle - Stress ellipsoid – Stress invariants – Principal stresses in 2-D and
3-D.

UNIT III 2 - D PROBLEMS IN CARTESIAN COORDINATES 9

Plane stress and plain strain problems - Airy's stress function – Biharmonic equations – 2-D problems – Cantilever and simply supported beams.

UNIT IV 2 - D PROBLEMS IN POLAR COORDINATES 12

Equations of equilibrium – Strain – displacement relations – Stress – strain relations – Airy's stress function – Axisymmetric problems - Bending of Curved Bars - Circular Discs and Cylinders – Rotating Discs and Cylinders - Kirsch, Boussinasque's and Michell's problems.

UNIT V TORSION 8

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15B3 HYPERSONIC AERODYNAMICS L T P C
3 0 0 3

OBJECTIVE:

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

UNIT I BASICS OF HYPERSONIC AERODYNAMICS 8

Thin shock layers – entropy layers – low density and high density flows – hypersonic flight paths hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS 9

Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS` 9

Approximate methods hypersonic small disturbance equation and theory – thin shock layer theory – blast wave theory - entropy effects - rotational method of characteristics - hypersonic shock wave shapes and correlations.

UNIT IV VISCOUS HYPERSONIC FLOW THEORY 10

Navier–Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating.

UNIT V VISCOUS INTERACTIONS IN HYPERSONIC FLOWS 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15B4 HIGH TEMPERATURE GAS DYNAMICS L T P C
3 0 0 3

UNIT I INTRODUCTION 8

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

UNIT II STATISTICAL THERMODYNAMICS 8

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

UNIT III KINETIC THEORY AND HYPERSONIC FLOWS 9

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

UNIT IV INVISCID HIGH TEMPERATURE FLOWS 10

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

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES 10

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15B5 ADVANCED PROPULSION SYSTEMS L T P C
3 0 0 3

OBJECTIVE

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

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

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

UNIT II RAMJETS AND AIR AUGMENTED ROCKETS 8

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

UNIT III SCRAMJET PROPULSION SYSTEM 12

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

UNIT IV NUCLEAR PROPULSION 9

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

UNIT V ELECTRIC AND ION PROPULSION 8

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

TOTAL: 45 PERIODS

TEXT BOOKS

1. G.P. Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 1998.

2. William H. Heiser and David T. Pratt, Hypersonic Airbreathing propulsion, AIAA Education Series, 2001.

REFERENCES

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

AE15B6 EXPERIMENTAL METHODS IN FLUID MECHANICS L T P C
3 0 0 3

UNIT I BASIC MEASUREMENTS IN FLUID MECHANICS 8

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

UNIT II WIND TUNNEL MEASEUREMENTS 8

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

UNIT III FLOW VISUALIZATION AND ANALOGUE METHODS 10

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

UNIT IV PRESSURE, VELOCITY AND TEMPERATURE EASUREMENTS 10

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

UNIT V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS 9

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES

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

AE15B7 SPACE MECHANICS L T P C
3 0 0 3

OBJECTIVE

To study the basic concepts of orbital Mechanics with particular emphasis on interplanetary trajectories

UNIT I BASIC CONCEPTS 4

The Solar System – References Frames and Coordinate Systems – The Celestial Sphere– The Ecliptic – Motion of Vernal Equinox – Sidereal Time – Solar Time – Standard Time –The Earth’s Atmosphere.

UNIT II THE GENERAL N-BODY PROBLEM 10

The many body Problem – Lagrange – Jacobian Identity –The Circular Restricted Three Body Problem – Libration Points- Relative Motion in the N-body Problem –Two –Body Problem – Satellite Orbits – Relations Between Position and Time – Orbital Elements.

UNIT III SATELLITE INJECTION AND SATELLITE ORBIT PERTURBATIONS 12

General Aspects of satellite Injections – Satellite Orbit Transfer –Various Cases – Orbit Deviations Due to Injection Errors – Special and General Perturbations – Cowell’s Method– Encke’s Method – Method of vibrations of Orbital Elements – General Perturbations Approach.

UNIT IV INTERPLANETARY TRAJECTORIES 6

Two Dimensional Interplanetary Trajectories –Fast Interplanetary Trajectories – Three Dimensional Interplanetary Trajectories – Launch if Interplanetary Spacecraft – Trajectoryabout the Target Planet.

UNIT V BALLISTIC MISSILE TRAJECTORIES AND MATERIALS 13

The Boost Phase – The Ballistic Phase –Trajectory Geometry- Optimal Flights – Time of Flight – Re – entry Phase – The Position of the Impact Point – Influence Coefficients. Space Environment – Peculiarities – Effect of Space Environment on the Selection of Spacecraft Material.

TOTAL: 45 PERIODS

TEXT BOOK

1. Cornelisse, J.W., “Rocket Propulsion and Space Dynamic”, W.H. Freeman & Co., 1984.

REFERENCES

1. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley, 1993.

2. Van de Kamp, P., “Elements of Astro-mechanics”, Pitman, 1979.
3. Parker E.R., “Materials for Missiles and Spacecraft”, McGraw-Hill Book Co. Inc., 1982.

AE15B8 CRYOGENICS L T P C
3 0 0 3

OBJECTIVE

To study the engineering concept of cryogenic and its application in various field

UNIT I FUNDAMENTALS OF CRYOGENICS 12

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 12

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 12

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 12

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

TOTAL: 45 PERIODS

REFERENCES

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

AE15B9 WIND ENGINEERING L T P C
3 0 0 3

UNIT I THE ATMOSPHERE: 6

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

UNIT II ATMOSPHERIC BOUNDARY LAYER: 9

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

UNIT III BLUFF BODY AERODYNAMICS: 10

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

UNIT IV WIND LOADING 10

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

UNIV V AEROELASTIC PHENOMENA: 10

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

TOTAL: 45 PERIODS

TEXT BOOKS

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

REFERENCES:

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

AE15C1 COMBUSTION ENGINEERING L T P C
3 0 0 3

UNIT I: FUNDAMENTAL CONCEPTS IN COMBUSTION, CHEMICAL KINETICS AND FLAMES 9

Thermo chemical equations – heat of reaction- first, second and third order reactions – premixed flames – diffusion flames – measurement of burning velocity – various

methods – effect of various parameters on burning velocity – flame stability – deflagration – detonation – Rankine-Hugoniot curves – radiation by flames.

UNIT II: COMBUSTION IN AIRCRAFT PISTON ENGINES 8

Introduction to combustion in aircraft piston engines – various factors affecting the combustion efficiency - fuels used for combustion in aircraft piston engines and their selection – detonation in piston engine combustion and the methods to prevent the detonation.

UNIT III: COMBUSTION IN GAS TURBINE AND RAMJET ENGINES 10

Combustion in gas turbine combustion chambers - recirculation – combustion efficiency, factors affecting combustion efficiency, fuels used for gas turbine combustion chambers – combustion stability – ramjet combustion – differences between the design of ramjet combustion chambers and gas turbine combustion chambers- flame holders types – numerical problems.

UNIT IV: SUPERSONIC COMBUSTION 9

Introduction to supersonic combustion – need for supersonic combustion for hypersonic airbreathing propulsion- supersonic combustion controlled by diffusion, mixing and heat convection – analysis of reactions and mixing processes - supersonic burning with detonation shocks - various types of supersonic combustors.

UNIT V: COMBUSTION IN SOLID, LIQUID AND HYBRID ROCKETS 9

Solid propellant combustion - double and composite propellant combustion – various combustion models – combustion in liquid rocket engines – single fuel droplet combustion model – combustion hybrid rockets

TOTAL: 45 PERIODS

TEXT BOOKS

1. Sharma, S.P., and Chandra Mohan, “Fuels and Combustion”, Tata Mc. Graw Hill Publishing Co., Ltd., New Delhi, 1987.
2. Mathur, M.L., and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers and Distributors, Delhi, 1988.

REFERENCES

1. Loh, W.H.T., “Jet, Rocket, Nuclear, Ion and Electric Propulsion: Theory and Design”, Springer Verlag, New York, 1982.
2. Beer, J.M., and Chiger, N.A. “Combustion Aerodynamics”, Applied Science Publishers Ltd., London, 1981.
3. Sutton, G.P., “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 5th Edition, 1993.

AE15C2 **AVIONICS** **L T P C**
3 0 0 3

OBJECTIVE

To introduce the basic concepts of navigation & communication systems of aircraft.

UNIT I INTRODUCTION TO AVIONICS **8**

Need for Avionics in civil and military aircraft and space systems – Integrated Avionics system – Typical avionics sub systems – Design approaches and recent advances - Application Technologies.

UNIT II PRINCIPLES OF DIGITAL SYSTEMS **10**

Digital Computers – Digital number system- number systems and codes-Fundamentals of logic and combinational logic circuits –Digital arithmetic – interfacing with analogue systems - Microprocessors – Memories.-

UNIT III DIGITAL AVIONICS ARCHITECTURE **8**

Avionics system architecture– salient features and applications of Data buses MIL–STD 1553 B–ARINC 429–ARINC 629.

UNIT IV FLIGHT DECK AND COCKPITS **9**

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

UNIT V AVIONICS SYSTEMS **10**

Communication Systems - Navigation systems - Flight control systems - Radar electronicwarfare - Utility systems Reliability and maintainability - Certification.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Malcrno A.P. and Leach, D.P., “Digital Principles and Application”, Tata McGraw-Hill, 1990.
2. Gaonkar, R.S., “Microprocessors Architecture – Programming and Application”, Wiley and Sons Ltd., New Delhi, 1990.

REFERENCES

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. Brain Kendal, “Manual of Avionics”, The English Book House, 3rd Edition, New Delhi, 1993.

AE15C3 CONTROL AND GUIDANCE 3 0 0 4

OBJECTIVES

- To provide operating principles and design of guidance of the missile and launch vehicles.
- To study the need for auto flight control system.
- To study the longitudinal and lateral auto pilot.

UNIT-I INTRODUCTION 8

Introduction to navigation, Guidance and control- definition, Historical backround

UNIT-II MISSILE AND LAUNCH VEHICLE GUIDANCE 9

Operating principles and design of guidance laws, Homing guidance laws- short range , medium range and BVR missiles , Launch vehicles- Introduction, Mission requirements, Implicit guidance schemes, Explicit guidance, Q guidance schemes.

UNIT-III AUGMENTATION SYSTEMS 9

Need for automatic flight control systems, Stability augmentation systems, control augmentation systems, Gain scheduling concepts.

UNIT-IV LONGITUDINAL AUTOPILOT 10

Displacement Autopilot- Pitch Orientation Control system, Acceleration Control system, Glide Slope Coupler and Automatic Flare Control and Flight path stabilization, Longitudinal control laws and design using back stepping algorithm.

UNIT-V LATERAL AUTOPILOT 9

Damping of the Dutch Roll, Methods of Obtaining Coordination, Yaw Orientation Control system, turn compensation, Automatic lateral Beam Guidance. Introduction to Fly-by-wire flight control systems, Lateral control law design using stepping algorithm.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Blakelock.J.H. ‘Automatic control of Aircraft and Missiles’ , John Wiley Sons, New York, 1990
2. Stevens.B.L. & Lewies F.L. ‘ Aircraft control & simulation’ John Wiley Sons, New York, 1992

REFERENCES

1. Collinson R.P.G. ‘ Introduction to Avionics’ , Chapman and Hall, India, 1996.
2. Garnel.P. & East.D.J. ‘Guided Weapon control systems’ Pergamon Press, Oxford,1997
3. Nelson R.C. ‘Flight stability & automatic control’ McGraw Hill, 1989.
4. Bernard Etikin, ‘Dynamic of flight stability and control’ , John Wiley, 1972.