Semester-3		Contact Hrs.			Marks			Credits
Code	Name	L	T	P	Int.	Ext.	Total	
BANE1-301	Fluid Mechanics	3	1	0	40	60	100	4
BANE1-302	Mathematics - III	3	1	0	40	60	100	4
BANE1-303	Introduction To Aeronautics	3	0	0	40	60	100	3
BANE1-304	Aerodynamics - I	3	0	0	40	60	100	3
BANE1-305	Strength of Materials - I	3	0	0	40	60	100	3
BANE1-306	Machine Drawing	1	0	4	40	60	100	3
BANE1-307	Workshop Training Of 4 Weeks duration After 2nd semester	0	0	0	60	40	100	2
BANE1-308	Strength of Materials Lab	0	0	2	60	40	100	1
BANE1-309	Fluid Mechanics Lab	0	0	2	60	40	100	1
Total		16	2	8	420	480	900	24

Total Contact Hours=26 **Total Marks=900** **Total Credits=24**

Semester-4		Contact Hrs.			Marks			Credits
Code	Name	L	T	P	Int.	Ext.	Total	
BANE1-410	Numerical Analysis	3	1	0	40	60	100	4
BANE1-411	Thermodynamics	3	1	0	40	60	100	4
BANE1-412	Aircraft Structures - I	3	1	0	40	60	100	4
BANE1-413	Aircraft materials and Processes	3	0	0	40	60	100	3
BANE1-414	Aircraft Propulsion - I	3	0	0	40	60	100	3
BANE1-415	Theory of Machines-1	3	0	0	40	60	100	3
BANE1-416	Aircraft propulsion and Material Processes lab	0	0	2	30	20	50	1
BANE1-417	Aircraft Structure - I Lab	0	0	2	30	20	50	1
Total		18	3	4	300	400	700	23

Total Contact Hours=25 **Total Marks=700** **Total Credits=23**

*__NOTE:__ During the summer vacation after 4th/ 6th semester, students are ready for industrial experience. Therefore, they may choose to undergo Internship / Innovation / Entrepreneurship related activities. Students may choose either to work on innovation or entrepreneurial activities resulting in start-up or undergo internship with industry/ NGO's/ Government organizations/ Micro/ Small/ Medium enterprises to make themselves ready for the industry.

Semester-5		Contact Hrs.			Marks			Credits
Code	Name	L	T	P	Int.	Ext.	Total	
BANE1-518	Aircraft Systems and Instrumentation	3	1	0	40	60	100	4
BANE1-519	Aerodynamics - II	3	1	0	40	60	100	4
BANE1-520	Aircraft Structures - II	3	1	0	40	60	100	4
BANE1-521	Aircraft Propulsion - II	3	0	0	40	60	100	3
BANE1-522	Aircraft Performance	3	0	0	40	60	100	3
BANE1-523	Aero Computing Lab	0	0	2	30	20	50	1
BANE1-524	Aircraft Systems Lab	0	0	2	30	20	50	1
BANE1-525	**Industrial Training of 6 weeks undergone after 4th semester(Training-II)**	-	-	-	60	40	100	3
Total		**15**	**3**	**4**	**320**	**380**	**700**	**23**

Total Contact Hours=22 **Total Marks=700** **Total Credits=23**

Semester-6		Contact Hrs.			Marks			Credits
Code	Name	L	T	P	Int.	Ext.	Total	
BANE1-626	Automatic Flight Control	3	1	0	40	60	100	4
BANE1-627	Aircraft Stability and Control	3	1	0	40	60	100	4
BANE1-628	Elements of Spacecraft Engineering	3	1	0	40	60	100	4
BANE1-629	Helicopter Engineering	3	0	0	40	60	100	3
BANE1-630	Elements of Avionics	3	0	0	40	60	100	3
BANE1-631	Wind Tunnel Techniques	3	0	0	40	60	100	3
BANE1-632	Aeromodelling and Design Lab	0	0	2	30	20	50	1
BANE1-633	Aircraft instrumentation and Measurement lab	0	0	2	30	20	50	1
Total		**18**	**3**	**4**	**300**	**400**	**700**	**23**

Total Contact Hours=25 **Total Marks=900** **Total Credits=23**

Semester-7		Contact Hrs.			Marks			Credits
Code	Name	L	T	P	Int.	Ext.	Total	
BANE1-734	High Speed Aerodynamics	3	0	0	40	60	100	3
BANE1-735	Aeroelasticity	3	0	0	40	60	100	3
BANE1-736	Airplane Design I	3	0	0	40	60	100	3
BANE1-737	Theory of Elasticity	3	0	0	40	60	100	3
BANE1-738	Project-I	0	0	8	120	80	200	4
BANE1-739	**Training-III**	-	-	-	60	40	100	4
	Department Elective-I*	3	0	0	40	60	100	3
BANE1-756	Principles of Management and Professional Ethics							
BANE1-757	Viscous Flow Theory							
BANE1-758	Aircraft Maintenance and Air Transportation							
Total		**15**	**0**	**8**	**380**	**420**	**800**	**23**

Total Contact Hours=23 **Total Marks=800** **Total Credits=23**

*One of the Departmental elective subjects to be selected by candidate

Semester-8		Contact Hrs.			Marks			Credits
Code	Name	L	T	P	Int.	Ext.	Total	
	Departmental Elective-II	3	1	0	40	60	100	4
BANE1-859	Boundary Layer Theory							
BANE1-860	Advanced Aerodynamics							
BANE1-861	Experimental Aerodynamics							
XXXX	Open Elective-I	3	0	0	40	60	100	3
XXXX	Open Elective--II	3	0	0	40	60	100	3
BANE1-840	Project-II	0	0	8	60	40	100	4
Total		**9**	**1**	**8**	**180**	**220**	**400**	**14**

Total Contact Hours=18 **Total Marks=400** **Total Credits=14**

NOTE: Choose any one subject for open elective and if studied choose another from rest of them

3rd Semester

BANE1-301 Fluid Mechanics-I

L T P C **Duration – 60 Hrs.**

3 1 0 4

UNIT – I

1. **Fluid and their properties**: Concept of fluid, difference between solids, liquids and gases; ideal and real fluids; capillarity, vapour pressure, compressibility and bulk modulus; Newtonian and non-Newtonian fluids.
2. **Fluid Statics**: Concept of pressure, Pascal's law and its engineering applications, Hydrostatic paradox. Action of fluid pressure on a plane (horizontal, vertical and inclined) submerged surface, resultant force and center of pressure, force on a curved surface due to hydrostatic pressure. Buoyancy and flotation, stability of floating and submerged bodies, metacentre height and its determination, periodic time of oscillation, pressure distribution in a liquid subjected to constant horizontal/ vertical acceleration, rotation of liquid in a cylindrical container.

UNIT – II

3. **Fluid Kinematics** : Classification of fluid flows, velocity and acceleration of fluid particle, local and convective acceleration, normal and tangential acceleration, streamline, path line and streak line, flow rate and discharge mean velocity, continuity equation in Cartesian and cylindrical, polar coordinates.

   Rotational flows, rotation velocity and circulation, stream and velocity potential functions, flow net.
4. **Fluid Dynamics** : Euler's equation, Bernoulli's equation and steady flow energy equation; representation of energy changes in fluid system, impulse momentum equation, kinetic energy and momentum correction factors, flow along a curved streamline, free and forced vortex motions.

UNIT – III

6. **Dimensional Analysis and Similitude**: Fundamental and derived units and dimensions, dimensional homogeneity. Rayleigh's and Buckingham's Pi method for dimensional analysis. Dimensionless numbers and their significance, geometric, kinematic and dynamic similarity, model studies. Laminar and Turbulent Flows: Flow regimes and Reynlods number, critical velocity and critical Reynolds number, laminar flow in circular cross- section pipes. Turbulent flows and flow losses in pipes, Darcy equation, minor head losses in pipes and pipe fittings, hydraulic and energy gradient lines.

UNIT – IV

7. **Flow Measurement**: Manometers, pitot tubes, venturi meter and orifice meters, orifice, mouthpieces,

   notches and weirs, rotameter.

Suggested Readings / Books:

- Fluid Mechanics and Fluid Power Engineering by D.S. Kumar : S.K. Kataria and Sons Publishers.
- Mechanics of Fluids by Massey BS; Van Nostrand Reinhold Co.
- Fluid Mechanics by Douglas JF, Gasiorek JM, Swaffield JP; Poitman
- Fluid Mechanics by Streetes VL and Wylie EB; Mcgraw Hill Book Co.

BANE1-302 MATHEMATICS-III

L T P C **Duration – 60 Hrs.**

3 1 0 4

UNIT – I

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.

UNIT – II

4. **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.

UNIT – III

5. **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.

UNIT – IV

6. **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 Readings / 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.

BANE1-303 Introduction to Aeronautics

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. Introduction

History of aviation, History of space flight, History of Indian space experience, Pre Wright Brothers era, Wright Flyer, Conventional airplane, progress in airplane design and applications, Current status. Other kinds of heavier than air vehicles, helicopter, VSTOL machines. Symbology of Aerospace : US Deptt of defence Aerospace Vehicle Designation, Vehicle Type Symbol : G-H-Q-S-V-Z; Basic Mission Symbols : A-B-C-E-F-AL-O-P-Q-S-T-U-X; Modified Mission Symbols : A-C,D,E,F,H,K,L,M,O,P,Q,R,S,T,U,V,W; Rocket Symbols : B,M,N,R,S; Manufacturers of Aerospace Vehicle in India-Aircraft, Space Vehicles, Main Aircraft operators in India; Aircraft Certification : Type certification, Airworthiness, CAA, FAA, DGCA, ICAO, Aircraft registration & marking of aircraft registered in India VT-AAA-ZZZ,

VT HAA-HZZ, Introduction to Aircraft Communication System : Air Band Frequencies, Navigation-GPS, Instruments, Aircraft Flight Control System, Manual, Assisted, Stability Augmentation System,

utopilot, Fly by wire. Classification with examples : By flights regime; sub-Sonic, Supersonic, Hypersonic Flights By wing placement; High Wing, Low Wing, Mid Wing, Cruciform (X) Wing;

By Type : Aerostatic, Aerodynamic, FW, RW, Variable sweep, Mixed fixed-Rotary, surface effect vehicles. By Planforms : Rectangular, Elliptical, Delta, Double Delta, Ogive, By stall speed & wing span

: (I-VI) combination (A-III). System of Axes – Motion longitudinal (Roll axis), lateral (Pitch axis), vertical (Yaw axis) (x,y,z), velocity (u, v, w) and acceleration. Angles of rotation – Roll, Pitch, Yaw, Airfoil Nomenclature, Symmetric & Cambered Airfoil, Angle of Attack. Types of Missions ; Fly by, orbiter, atmospheric, lander, penetrator, observatory, Communicator, Aerospace mission of future.

Cockpit definition parts, seats, flight deck central column rudder pedal instrument panel, pedestal panel, side console, overhead panel, glass cockpit, joystick.

UNIT – II

2. Space Vehicles

Missile and its types, space vehicles and its types, reusable space vehicles, space shuttle ,satellites, types of satellites and their functions

3. Airplane Propulsion

Requirement of power to fly, balance of forces, various means of producing power for forward flight., piston engines ,jet propulsion-thrust equation, turbojet, turbofan, ramjet engines. Locations of such engines, Propellor and its use. Rocket engines.

UNIT – III

4. Airplane Structures & Materials

Structural arrangement of the Wright Flyer,. Structural details of landing gear, wing, fuselage and tail planes, functions of ribs, skin, spars, stringers, longerons. Monocoque and semi-monocoque structures,materials for main components

UNIT – IV

5. Control Systems & LEVEL FLIGHT

Various types of flaps, function of rudder, elevator, ailerons, flaprons, elevons, types of tail planes,condition for straight & level flight, flight path angle

Suggested Readings/ Books:

- Fundamentals of Flight Richard S. Shevel , Prentice Hall
- Introduction to flight- John D. Anderson
- Mechanics of flight by A.C. Kermode
- Aircraft Basic Science :Ralph D. Bent & James L. Mackinley
- Jet Aircraft Power Sysytem : Jack V.Casamassa & Ralph D.Bent

BANE1-304 Aerodynamics- I

L T P C **Duration – 45 Hrs.**

3 0 0 3

UNIT – 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.

UNIT – II

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 Bernaulli's equation for invisid and viscous flow fields. Momentum equation and angular momentum equation in integral form.

UNIT – III

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

UNIT – IV

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.

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Suggested Readings / 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
- Foundations of Fluid Mechanics: S.W.Yuan Prentice Hall

BANE1-305 Strength of Materials – I

L T P C **Duration – 45 Hrs.**

3 0 0 3

UNIT – 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

UNIT – II

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 contraflexure 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.

UNIT – III

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

UNIT – IV

7. **Columns and struts** : Columns and failure of columns : Euler's formuls; Rankine- Gordon's formula, Johnson's empirical formula for axially loaded columns and their applications.
8. **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 Readings/ 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.

BANE1-306 Machine Drawing

L T P C **Duration – 45 Hrs.**

1 0 4 3

UNIT – I

1. Principles of drawing, requirements of production drawing, sectioning and conventional representation, dimensioning, symbols of standard tolerances, machining symbols, Introduction and familiarization of the code IS:296.

UNIT – II

2. FASTENERS : Various types of screw threads, types of nuts and bolts, screwed fasteners, welding joints and riveted joints

UNIT – III

4. Assembly and Dis-assembly of the following manually and using computer aided drafting.

a) Couplings: Solid or rigid Coupling, Protected type flange coupling, Pin type flexible coupling, muff coupling, Oldham, universal coupling, claw coupling, cone friction clutch, free hand sketch of single plate friction clutch.

b) Knuckle and cotter joints

c) Pipe and Pipe fittings: flanged joints, spigot an socket joint, union joint, hydraulic an expansion joint

d) IC Engine Parts : Piston, connecting rod

e) Boiler Mountings : steam stop valve, feed check valve, safety valve, blow off cock.

f) Bearings : swivel bearing, thrust bearing, plummer block, angular plumber block

g) Miscellaneous : Screw Jack, Drill Press Vice, Crane hook.

Drafting of simple mechanical components on computer.

NOTE :

Drawing Practice is to be done as per IS:296 code.

First angle projection to be used. Drawings should contain bill of materials and should illustrate finish. The syllabus given above indicates the broad outlines and the scope of the subject to be covered. It is not necessary to cover all the drawing exercises of the types of machine tools mentioned above.

Suggested Readings/ Books:

- Text-book of Machine Drawing by V Lakshmi Narayanan and Mathur

- Machine Drawing by PS Gill, BD Kataria and Sons, Ludhiana
- Machine Drawing by ND Bhatt, Charotar publications
- Machine Drawing by N Sidheshwar, Tata McGraw Hill

BANE1-308 Strength of Materials Lab

L T P C
0 0 2 1

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.

BANE1-309 Fluid Mechanics –I Lab

L T P C
0 0 2 1

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

4th Semester

BANE1-410 Numerical Analysis

L T P C
3 1 0 4

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 4^{th} 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.

BANE1-411 Thermodynamics

L T P C **Duration – 60 Hrs.**
3 1 0 4

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.

BANE1-412 Aircraft Structures –I

L T P C **Duration – 60 Hrs.**
3 1 0 4

1. Basic Elasticity: Equations of equilibrium, plane stress, stresses on inclined planes, principal stresses, Mohr's circle of stress, strain, compatibility equations, plane strain, principal strains, stress-strain relationship**.**

2. 2-D Problems In Elasticity: 2- D problems, stress functions, inverse and semi inverse method, St. Venant principle, bending of end-loaded cantilever, torsion of solid sections, Prandtl stress function solution. St. Venant warping function solution.

3. Structural Analysis Method

Energy Method, strain energy, complimentary energy, principle of virtual work and virtual displacement, principle of superposition, Maxwell reciprocal theorem.

4. Statically Determinate And Indeterminate Structures

Statically determinate and indeterminate trusses. Truss analysis with single and double redundancy, other structures with single redundancy, frames and rings, shear lag.

5. Loads On Structural Components

Functions of structural components, factor of safety, limit load,V-n diagram, a/c inertia loads, symmetric maneuver loads, steady pull out, banked turn, gust loads.

6. Bending, Shear And Torsion Of Open And Closed Beams Section

Direct stress distribution and deflection due to bending, shear of open section, shear centre, shear and torsion of closed section, torsion of open section, analysis of combined open and closed sections.

7. Aircraft Joints And Fittings

Types of bolted or riveted joints, margin of safety, analysis of different types of fitting failures, standard parts, eccentrically loaded connection.

Suggested Reading/Books:

- Aircraft Structures for Engineering Students: T.H.G.Megson, Edward Arnold, Butterworth-Heinemann,
- Aircraft Structures: D.J.Peery, McGraw Hill
- Fundamentals of aircraft structural analysis: Howard D. Curtis, McGraw Hill
- Theory and Analysis of Flight Structures: RM Rivello, McGraw Hill

BANE1-413 AIRCRAFT MATERIALS AND PROCESSES

L T P C **Duration – 45 Hrs.**
3 0 0 3

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. COMPOSTE MATERIALS

Introduction, Fibers, glass fibers, carbon fibers, Aramid fibres, Baron Fibres, Engineering ceramix. Matrix Materials – Their functions, various types , curing of resins.

6. METAL JOINING PROCESSES

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

Suggested Reading/Books :

1. Workshop technology: WAJ Chapman, Replika Press Pvt. Ltd.
2. Aircraft Material and Processes: G F Titterton, Himalayan Books, New Delhi.
3. Advanced Composite materials: Lalit Gupta, Himalayan Books, New Delhi,

BANE1-414 AIRCRAFT PROPULSION -I

L T P C **Duration – 45 Hrs.**
3 0 0 3

1. CONDUCTION HEAT TRANSFER

Heat transfer process, heat conduction, thermal conductivity, general equations of heat conduction, Newton- Rikhman law, conduction problems.

2. CONVECTION AND RADIATION HEAT TRANSFER

Convection process, free convection heat transfer from vertical flat plate, planes, cylinder and sphere, free convection in enclosed space, effect of laminar and turbulent flow on convection process, combined free and forced convection. Thermal radiation and emissive power, Planck distributive law, radiation properties.

3. PROPELLERS

Ideal momentum theory, blade element theory, activity factor, airscrew coefficients, numerical problems on the performance of propellers, selection of propellers, fixed, variable and constant speed propellers, material for propellers, momentum theory applied to helicopter rotor.

4. AIRCRAFT PISTON ENGINES

The internal combustion engine process, brief history, G.I and C.I engines, 4-stroke and 2-stroke engines, air standard cycles, various types of arrangements for multi-cylinder aircraft engines, merit and operational efficiencies, cooling, lubricating and ignition systems, valve timing diagrams, I.H.P, B.H.P. and S.H.P., performance, effect of altitude, power required and power available, supercharging.

5. AIRCRAFT GAS TURBUNE ENGINES

Air standard Brayton cycle, actual gas turbine engine cycle, compressor and turbine efficiencies **,** compressor and turbine work, centrifugal and axial type of compressors, their compressive action, relative merits in operations, combustion chambers, simplex and duplex burners, expansion process, turbine materials for different components, engine intake and exhaust nozzles, afterburners, thrust augmentation, turboprop, turbo shaft and turbofan engines, multi shaft gas turbine engines, thrust equation, installed and uninstalled thrust.

Suggested Reading/Books :

1. Heat transfer: J.P.Holman, McGraw Hill.

2. I.C.Engines: L.C.Litchy**,** McGraw Hill.

3. Gas Turbine Theory: Cohen, Rogers and Saravanamuttu, Pearson Education .

4. Heat transfer: B.Gebhart,McGraw Hill.

5. Elements of Gas Turbine Propulsion: J.D. Mattingly, McGraw Hill.

BANE1-415 THEORY OF MACHINES-I

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

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 components).

UNIT – II

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.

UNIT – III

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).

UNIT – IV

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 governors. 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

BANE1-416 AIRCRAFT PROPULSION AND MATERIAL PROCESSES LAB

L T P C
0 0 2 1

Any five of the following :

1. To study the functioning of aircraft piston engines having various arrangements of cylinders .
2. To study the functioning of aircraft gas turbine engines .
3. Experiments on solid propellant test rig.
4. Experiments on continuous combustion test rig.
5. Heat treatment of steel alloys, study of microstructure before and after heat treatment.
6. Exercises in welding, riveting and spot welding.
7. Fabricating of fuselage and wing panels/parts.

BANE1-417 AIRCRAFT STRUCTURES – I LAB

L T P C
0 0 2 1

List of Practicals

1. Bending tests, Stresses and deflections of beams for various end conditions.
2. Compression tests on long and short columns, critical buckling loads, southwell plot.
3. Tests on riveted and bolted joints.
4. Combined bending and torsion of a hollow circular tube.
5. Shear centre of a channel section (open section).
6. Free vibration of a cantilever beam.
7. Shear centre of channel section (closed section).

5th Semester

BANE1-518 AIRCRAFT SYSTEMS AND INSTRUMENTATION

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. FLIGHT CONTROL SYSTEMS

Primary and secondary flight control, flight control linkage systems, push-pull control rod system, cable and pulley systems, high lift control systems, flight control actuation, linear actuator, mechanical actuator, mechanical screw-jack actuator, direct drive actuation, fly-by-wire actuator, electro-hydrostatic actuator, electro-mechanical actuator .

UNIT – II

2. ENGINE CONTROL SYSTEMS

Engine technology and principle of operation, fuel flow control, air flow control, control systems, control system parameters, input signals, output signals, engine starting, fuel control, ignition control, engine rotation, throttle levers, starting sequence, engine oil systems.

3. HYDRAULIC AND ENVIRONMENT CONTROL SYSTEMS

Hydraulic circuit design, hydraulic actuation, hydraulic fluid, fluid pressure and temperature, fluid flow rate, hydraulic piping and pumps, need for controlled environment, heat sources, ram air cooling, fuel cooling, engine bleed, bleed flow and temperature control, air cycle, refrigeration, humidity control, hypoxia, tolerance.

UNIT – III

4. PITOT STATIC INSTRUMENTS & SYSTEMS

Pitot static system, air speed indicator, altimeter, mach-meter, mach/airspeed indicator, vertical speed indicator.

5. GYROSCOPIC INSTRUMENTS

Gyroscope and its properties, gyro-horizon, turn and bank indicator, turn coordinator, direct reading magnetic compass, directional gyroscope.

UNIT – IV

6. NAVIGATIONAL INSTRUMENTS

Very high and ultra high frequency radio aids,VOR,TACAN,VORTAC,VHF direction finding, instrument landing system, microwave landing system.

Suggested Reading/Books :

- Aircraft systems: Ian Moir and Allan Seabridge
- Aircraft instruments: E H J Pallet

BANE1-519 Aerodynamics – II

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – II

1. CONFORMAL TRANSFORMATION

Complex potential function, Blasius theorem, principles of conformal transformation, Kutta - Juokowaski transformation of a circle into flat plate, airfoils & ellipses.

UNIT – II

2. INCOMPRESSIBLE FLOW OVER AIRFOILS

Glauert's thin airfoil theory, symmetrical airfoil, cambered airfoil, flapped airfoil, determination of mean camber line shapes for uniform & linear distribution of circulation. Description of flow about multi-element airfoils.

3. INCOMPRESSIBLE FLOW OVER FINITE WINGS

Downwash & induced drag, Biot-Savart's law and Helmholtz's theorem, Prandtl's classical lifting line theory, fundamental equations. Elliptic and general lift distribution over finite unswept wings, effect of aspect ratio, Drag polar ,Correlation of C_l distribution over other aspect ratios, Lifting Surface theory, Formation Flying, Ground effect.

UNIT – III

4. COMPUTATIONAL AERODYNAMICS OF AIRFOILS AND WINGS

Computation of flow field due to distribution of source doublet and line and horse shoe vortices, vortex lattice method, wing as a planar surface covered with HSVs. Panel methods: source ,doublet and vortex based panel methods for airfoils and wings of rectangular planform.Extension to elliptic and swept back planforms.

5. DELTA WING AERODYNAMICS

Polhamus theory, leading edge suction analogy, calculations of lift coefficient, flow field, aspect ratio effect, leading edge extension, HAA aerodynamics

UNIT – IV

6. COMPRESSIBLE SUBSONIC FLOWS OVER AIRFOILS

The derivation of velocity potential equation. Linearization , Prandtl-Glauert compressibility correction. Karman –Tsien correction, Critical Mach number, Whitcomb's area rule, Supercritical airfoil.

Suggested Reading/Books :

1. Fundamentals of Aerodynamics : John D.Anderson, McGraw Hill.
2. Aerodynamics for Engineers : Bertin and Smith, Prentice Hall.

BANE1-520 Aircraft Structures – II

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. ELASTICITY OF COLUMNS

Euler column, higher order differential equations for columns, energy approach, dynamic approach of predicting buckling loads, approximate methods for prediction of buckling loads, Effect of shear on buckling loads, Large deflection of columns, Columns with eccentricity in geometry, Open section columns, Torsional buckling of open section columns, Flexural torsional buckling of open section columns.

UNIT – II

2. STABILITY OF ELASTIC PLATES

Governing differential equation for stability of plates under uni-axial compressive loads, Energy equation for appropriate solution for bucking loads, Rayleigh Ritz technique, Galerkin technique, Buckling loads under biaxial compressive loads & shear loads, Finite difference equations for estimating buckling loads, Buckling of stiffened plates, Buckling of plates with different boundary conditions.

3. POST BUCKLING BEHAVIOUR OF PLATES

Concept of effective width, buckling behavior of plates, Elastic buckling of flat plates, Elastic buckling of curved rectangular plates.

UNIT – III

4. DESIGN OF WEBS IN SHEAR

Pure tension field beams, diagonal tension, semi tension field beams, curved tension field webs.

5. INTRODUCTION TO MATRIX METHODS IN STRUCTURAL ANALYSIS

Introduction of flexible and stiffness methods, choice of method, stiffness matrix for an elastic spring, analysis of pin jointed framework, Matrix analysis of space frames, stiffness matrix for uniform beams.

UNIT – IV

7. INTRODUCTION TO FEM METHOD IN STRUCTURAL ANALYSIS

Mathematical idealization of the structure, elements of discretization, application of FEM, stiffness method concept formulation, formulation procedure for element structural relationship, element shape function , from element to system formulation. Simple problems

Suggested Reading/Books :

- Aircraft Structures for Engineering Students : T.H.G.Megson, Elsevier.
- Structural Stability of Columns and Plates : NGR Iyengar, Affiliated East-West Press (Pvt) Ltd.
- Introduction to Structural Stability : C.Chajis, Prentice Hall Inc. Engle Wood Cliff.
- Aircraft Structures : David J.Perry, McGraw Hill.
- Theory and Analysis of Flight Structures : RM Rivello, McGraw Hill.
- Introduction to Finite Elements in Engineering: T.R Chandruplata and A.D Belagundu, PHI.

BANE1-521 Aircraft Propulsion – II

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. INTRODUCTION TO GAS DYNAMICS

Basics, simple flows, nozzle flow and design, nozzle operating characteristics for isentropic flow , shock waves in nozzle flow, Rayleigh flow and fanno flow effect of frictional duct length in subsonic and supersonic flow, numerical problems in 1-D flow. Scram jet, pulse jet and ram jet.

UNIT – II

2. INLETS AND NOZZLES

Subsonic inlets, pressure recovery, inlet sizing, supersonic inlets and mass flow characteristics, inlet design and sizing, exhaust nozzles, thrust reversing and thrust vectoring, nozzle coefficients, nozzle performance.

3. AXIAL FLOW COMPRESSOR

Euler's turbo machinery equations, axial flow compressor analysis, cascade theory, velocity diagrams, flow annulus area stage parameters, degree of reaction, axial flow compressor coefficients, stage p pressure ratio, repeating stage-repeating row-mean line design ,performance and design.

UNIT – III

4. AXIAL FLOW TURBINE

Introduction to turbine analysis, velocity diagrams, mean radius stage calculations, stage parameters, loading and flow coefficients, degree of reaction, axial flow turbine stage analysis, performance and design.

5. INTRODUCTION TO ROCKET PROPULSION

Rocket propulsion, early history of rocket flights, applications of rocket propulsion, definitions and fundamentals, solid rocket fundamentals, solid and liquid propellants in details.

UNIT – IV

6. SOLID ROCKET COMPONENTS AND MOTOR DESIGN

Motor case, nozzle, igniter hardware, rocket motor design, performance of rocket vehicles, space missions, rocket staging.

Suggested Reading/Books :

1. Elements of Gas Turbine Propulsion: J.D. Mattingly, McGraw Hill.

2. Rocket Propulsion Elements: George P. Sutton, Oscar Biblarz, John Wiley & Sons.

3. Gas Turbine Theory: Cohen, Rogers and Sarvanmatto, John Wiley

4 .Mechanics and Thermodynamics of Propulsion: P.G.Hill & Peterson, Addison- Wesley.

BANE1-522 Aircraft Performance

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. The Standard Atmosphere and Airflow

UNIT – II

2. Aerodynamic Drag

Cause of Drag, its effects, types of drag and affecting factors. Drag polar, compressibility drag, design for minimum drag, estimation of drag of complete airplane, Terminal Velocity.

3. Aerodynamic Characteristics

Force and Moments coefficients from dimensional analysis. Pressure distribution over 2-D airfoil, variation with angle of attack, center of pressure, aerodynamic center, problems connected with them. Lift, Drag and moment coefficients; Relations between lift and drag. Estimation of these characteristics from measured pressure distributions, variation of aerodynamic coefficients with Reynold's Number and Mach number. Effect of span, Aspect ratio, plan form, sweep, taper and twist on aerodynamic characteristics of a lifting surface. Delta wing Aerodynamics.

UNIT – III

4. High Lift Systems

Airfoil's maximum lift coefficient, leading and trailing edge devices, effect of sweep back. The deep stall. effect of Reynolds number, Propulsive lift, V/STOL configurations.

5. Airplane Performance in Steady Flight

Straight and Level flight, stalling speed; Variation of drag with flight. Speed conditions for minimum drag, minimum power conditions; Power at other speeds. Gliding flight, shallow and steep angles of glide; Sinking speed, minimum sinking speed, time of descent. Climbing flight at shallow angles, correction for steep angles, time to flight, maximum rate of climb.

UNIT – IV

6. Airplane Performance in Accelerated Flight

Take-off and landing, calculations of take-off ground run, take off distances. Minimum ground run, assisted take-off, calculation of landing ground run. Range and endurance and problems connected with them.

7. Maneuvers

Introductory comments on spins and stalls; turning flight, maneuvers in 3-D space.

Suggested Reading/Books :

1. Introduction to Flight: J D Anderson , Mc Graw Hill.
2. Fundamentals of Aerodynamics: J D Anderson, Mc Graw Hill.
3. Aerodynamics for Engineering Students: E L Houghton and N.B. Carruthers, Arnold Publisher.

BANE1-523 Aero Computing Lab

L T P C
0 0 2 1

Using any Softwares like PRO/E, CATIA, Solid W orks, ANSYS, MSC / Nastran

1. Modeling of various components using any modeling software
2. Static analysis on cantilever beam
3. Static analysis of forces in a simply supported beam
4. Static analysis- Plane truss
5. 2-D static stress analysis
6. 3-D static stress analysis
7. Stress distribution in a shrink fit
8. Natural frequencies of a spring mass system

BANE1-524 Aircraft Systems Lab

L T P C
0 0 2 1

Study of any five of the following aircraft systems :

1. Hydraulic system
2. Mechanical system
3. Pneumatic system
4. Electrical system
5. Fly-by-wire system
6. Fuel system

BANE1-525 Industrial Training

Industrial Training of 6 weeks undergone after 4th semester

6th Semester

BANE1-626 Automatic Flight control

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. INTRODUCTION

Open Loop and Closed Loop (Feed Back) control systems. Types of feedback control systems.

2. FEED BACK CONTROL SYSTEM

Transfer function of linear systems. Impulse response of linear systems, Block diagrams of feed back control systems, Multivariable systems, Block diagram algebra.

UNIT – II

3. ANALYSIS OF FEEDBACK CONTROL SYSTEMS

Typical test input signals, Time domain performance characteristics of feedback control systems. Effects of derivative and integral control. Steady State response of feedback control system-steady State error, Frequency response.

UNIT – III

4. SYSTEM STABILITY Routh-Hurwitz
Criterion, the Root Locus Method.

UNIT – III

5. LONGITUDINAL AUTO-PILOTS

Longitudinal Auto Pilots: Brief description through Block diagrams and Root Locus of Displacement, Auto Pilot, Pitch Orientational Control System. Acceleration control system. Fly-By-Wire control system, Instrument Landing System.

UNIT – IV

6. LATERAL AUTO PILOTS

Introduction, Damping of the Dutch Roll, Methods of Obtaining coordination, Yaw orientational control system

Suggested Reading/Books :

1. Automatic Control of aircraft and Missiles : John H.Blackelock, John Wiley & Sons.
2. Airplane Performance Stability and Control: C.D. Perkins and R.E. Hage, John Wiley & Sons.

3. Dynamics of Flight: Stability and Control: Bernard Etkins, John Wiley & sons.

4. Flight Stability and Automatic Control: Robert C. Nelson, McGraw Hill.

5. Automatic Flight Control: EHJ Pallet, B.S. Professionals Books, Oxford.

6. Automatic Control Systems: Benjamin C.Kuo, Prentice Hall of India, New Delhi.

BANE1-627 Aircraft Stability and Control

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. Stick Fixed Static Longitudinal Stability

Introduction to stability of airplane, stick fixed longitudinal stability, effect of power, Neutral point, Centre of gravity limits. In flight measurement of stick fixed neutral point.

2. Control Surfaces and Aerodynamic Balancing

Control surface hinge moments, floating and restoring tendencies, different types of tabs used on airplanes. Frise Aileron, Spoiler Controls.

UNIT – II

3. Stick Free Static Longitudinal Stability

Effect of free elevator on airplane stability, Elevator Control force, stick force gradients, Neutral point, Controls free center of gravity limit. In flight measurement of stick free neutral point.

UNIT – III

4. Maneuvering Flight

Effect of acceleration on airplane balancing, Elevator angle per g, and stick force per g, Maneuver margins.

5. Directional Stability and Controls

Asymmetric flight, Weather cock stability, contribution of different parts of Airplane, Rudder Fixed and Rudder free static directional stability, rudder lock.

UNIT – IV

6. Lateral Stability and Control

Dihedral Effect. Contribution of different parts of airplane, controls in Roll, Aileron control power, cross coupling of lateral and directional effects.

7. Dynamic Stability

Introduction to dynamics, spring-mass system. Equations of motion without derivation, stability derivatives, Longitudinal Dynamic Stability, Lateral and Directional Dynamic Stability, analysis of different stability modes

Suggested Reading/Books:

1. Airplane Performance Stability and Control: Perkins and Hage, John Wiley.
2. Dynamics of Flight: Bernard Etkin, John Wiley.
3. Flight Stability and Automatic Control: Robert C. Nelson, McGraw Hill.

BANE1-628 Elements of Spacecraft Engineering

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. INTRODUCTION

Introduction to spacecraft, rockets and missiles, their basic functions and features , elements of rocket propulsion.

2. 2-D ROCKET MOTION IN VACUUM

Equations of motion, rocket motion in free space, Tsiolkovsky's equation, rocket parameters, multistage rockets, ideal velocity of multistage rocket.

UNIT – II

3. TWO BODY PROBLEM

Orbit equation, Kepler's laws, circular orbit, elliptical, hyperbolic orbit, orbital elements

4. LAUNCHING OF SATELLITE

Launch vehicle ascent trajectories, injection of satellite and its general aspects, dependance of orbital parameters on in-plane injection parameters

UNIT – III

5. THE EARTH SATELLITE OPERATIONS

The Hohmann transfer, inclination-change maneuver, launch to rendezvous, decay life time, earth oblateness effect, low thrust orbit transfer.

6. SATELLITE ALTITUDE DYNAMICS

Torque –Free axisymmetric rigid body, general torque free rigid body, semi-rigid space craft, altitude control: Spinning and Non spinning space craft. The Yo-Yo mechanism, gravity gradient satellite, the dual spin spacecraft.

UNIT – IV

7. BALLISTIC MISSILE TRAJETORIES

Introduction, boost phase, ballistic phase, trajectory geometry, re-entry trajectory

Suggested Reading/Books:

1. Space Flight Dynamics: William E. Wiesel , Mc Graw Hill.
2. Rocket Propulsion & Spaceflight Dynamics: J W Cornelisse, H F R Schoyer, K F Wakker, Pitman Publishing Ltd.
3. Rocket Propulsion Elements: G.P Sutton, John Wiley and Sons.

BANE1-629 Helicopter Engineering

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. ELEMENTARY BLADE MOTION

Historical development of helicopter and overview, Basic concepts, Introduction to hovering and forward flight theory, Rotor blade motion – flapping, feathering and lagging motion, Composite structures.

UNIT – II

2. AERODYNAMICS OF THE ROTOR IN MOTION

The actuator-disc theory, Working states of rotor, Optimum rotor, Efficiency of rotor, Ground effect on lifting rotor, The effect of finite number of blades, Induced velocity and induced power in forward flight – Mangler and Squire method, flight and wind tunnel test, The vortex wake, Aerofoil characteristics in forward flight.

UNIT – III

3. HELICOPTER TRIM AND PERFORMANCE IN MOTION

Blade forces and motion in forward flight, Force, torque and flapping coefficient, Helicopter trim analysis, Performance in forward flight.

4. DYNAMIC STABILITY AND CONTROL

Longitudinal and lateral stability, Equations of motion, Stability characteristics, Auto stabilization, Control response.

UNIT – IV

5. HELICOPTER VIBRATIONS

Exciting forces, Fuselage response, Vibration absorbers, Measurement of vibration in flight.

Suggested Reading/Books :

1. Helicopter Dynamics : ARS Bramwell, John Wiley and Sons.
2. Helicopter Engineering : Lalit Gupta, Himalayan Publishers
3. Principles of Helicopter Engineering: Jacob Shapiro, Mc Graw Hill.
4. Introduction to Helicopter and Tilt rotor flight simulation : M.E. Drier, AIAAA Education series.

BANE1-630 Elements of Avionics

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. AVIONICS TECHNOLOGY

Processors, Memory Devices, Digital Data Buses –MIL-STD-1553B, ARINC 429, ARINC 629, Fiber Optic Buses, LRU architecture for avionics packaging, software, environmental effects, difference in avionics architecture of commercial and military aircraft.

UNIT – II

2. SENSORS

Air Data Sensing – Use of pitot static probe, static probe to derive air data indications; Role of Air Data Computer (ADC), Magnetic Sensing – Magnetic Heading Reference System (MHRS), Inertial Sensing – Position Gyros, Rate Gyros, Accelerometers, Radar Sensing - Radar Altimeter (RADALT), Doppler Radar, Weather Radar.

UNIT – III

3. DISPLAY

Comparison of earlier flight deck (Electromechanical type instruments) to modern flight deck (glass fight deck), Cathode Ray Tube (CRT), Active Matrix Liquid Crystal Display (AMLCD),

Head Down Display (HDD), Head Up Display (HUD),Helmet Mounted Display (HMD), Integrated Standby Instrument System (ISIS).

4. COMMUNICATION

HF, U/VHF, Satellite Communication , Air Traffic Control (ATC) Transponder, Traffic Collision & Avoidance System (TCAS), Identification of Friend & Foe (IFF).

UNIT – IV

5. NAVIGATION

Automatic Direction Finding, Very High Frequency Omni-Range (VOR), Distance Measuring Equipment (DME), Tactical Air Navigation (TACAN), VORTAC (VOR+TACAN) Satellite Navigation System-Global Positioning System (GPS), Differential GPS Instrument Landing System (ILS), Transponder Landing System (TLS), Microwave Landing System (MLS), Astronavigation.

6. AUTOMATIC FLIGHT CONTROL SYSTEM

Longitudinal, Lateral & Direction Autopilot.

Suggested Reading/Books :

1. Civil Avionics Systems: Ian Moir, Allan Seabridge, AIAA Education Series.
2. Aircraft System : Ian Moir & Allan Seabridge, John Wiley.
3. Aircraft Electricity & Electronics : T.K. Eismin, Macmillan.

BANE1-631 Wind Tunnel Techniques

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. Wind Tunnel as a Tool

Types of wind tunnels, special purpose wind tunnels.

2. Wind Tunnel Design

Test section, diffuser, fan section, fan design, return passage, cooling , The breather- vibration, test section flow quality, effuser design , wind tunnel construction , energy ratio, final form.

UNIT – II

3. Instrumentation and Calibration of Test Section

Measurement of pressure, velocity, turbulence, flow angularity, hot wire anemometry, laser velocitimeter, data acquisition, flow visualization techniques, wind tunnel calibration.

UNIT – III

4. Model Forces, Moment and Pressure Measurement

Wind tunnel balances- Internal & External balances, design of wind tunnel balances, Wake survey method.

5. Wind Tunnel Correction

Method of Images , boundary corrections, buoyancy corrections, wake blockage, solid blockage-(2-D & 3-D corrections).

UNIT – IV

6. Non-Aeronautical Uses of Wind Tunnel

Applications in wind engineering, Surface vehicle testing, testing of buildings for wind forces, pollution, other applications at low Reynolds numbers.

Suggested Reading/Books :

1. Low speed wind tunnel testing: W.E. Rae and A. Pope, John Wiley.
2. Measurement of Airflow: Pankhrust and Ower, Pergamon Press.

BANE1-632 Aeromodelling and Design Lab

L T P C
0 0 2 1

This laboratory Course is intended to bring out the talent in the students. It requires equal or even more work / thinking on the part of the instructor in-charge First formulate a simple problem known from the theory covered so far, work out a practical approach to demonstrate that there is yet another method to understand and demonstrate the problem and its solution. It could be a group task involving some fabrication work.

BANE1-633 Aircraft Instrumentation and Measurements Lab

L T P C
0 0 2 1

1. Study of various types of flight instruments.
2. Any four of the following experiments :

(a) Use of strain gauges

(b) Measurement of force, torque and power.

(c) Measurement of flow

(d) Measurement of pressure.

(e) Measurement of acoustics.

(f) Measurement of temperature.

7th Semester

BANE1-734 High Speed Aerodynamics

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. SHOCK WAVES

Introductory remarks, Point source in a compressible flow, Mach waves and shock waves. a)Normal shock waves: Equation of motion for a normal shock, Normal shock relations for a perfect gas, Stagnation conditions, RH relations, Propagating shock waves, weak shock, reflected shock wave, centered expansion waves, shock tube. Numerical examples b) Oblique shock waves: Introduction, Oblique shock relations, M-θ-β relations, Shock polar, Supersonic flow over wedge, Weak oblique shock, Supersonic compression, Detached shock, Numerical examples.

UNIT – II

2. EXPANSION WAVES

Supersonic expansion by turning, Prandtl-Meyer flow, Numerical problems. Simple and non-simple regions, Reflection and intersection of shocks and expansion waves, Mach reflections, Method of characteristics, Numerical examples.

3. LIFT AND DRAG IN SUPERSONIC FLOWS

Shock –Expansion theory, Flow field in supersonic flows, Numerical problems, Thin airfoil theory, Analytical determination of lift and drag coefficients on flat plate, Bi-convex, and diamond shaped sections in supersonic flows, Numerical problems, Supersonic leading and trailing edges.

UNIT – III

4. POTENTIAL EQUATION FOR COMPRESSIBLE FLOWS

Introduction, Crocco's theorem, Derivation of basic potential equation for compressible flows, Linearization of governing equation, Boundary conditions, Small perturbation theory, Application to wavy wall, Bodies of revolution.

5. AIRFOILS IN COMPRESSIBLE FLOW

Introduction, Linearized compressible flow, Airfoils in subsonic flow, Prandtl-Glauert transformation, Critical Mach number, Supercritical flows, Airfoils in transonic flow, Governing equations, Shock wave boundary layer interaction, Stability and control problems.

UNIT – IV

6. **MEASUREMENTS IN COMPRESSIBLE FLOWS**

Rayleigh's supersonic Pitot formula, Equipment used in supersonic flows, Supersonic wind tunnels, Heat transfer tunnels, Shock tunnels, Aero-ballistic ranges, Terminal ballistic range, Rocket sled facility, Special instrumentation for these types of tunnels. Suggested Readings / Books:

1. Modern compressible Flow: John D. Anderson, Mc Graw Hill.
2. Elements of Gas Dynamics: Lieppmann and Rosheko, John Wiley.
3. Experimental Methods in Hypersonic flows: J. Lucasiewisz, M Dekker.
4. Compressible Flows: S.M Yahya, New Age International Publisher.

BANE1-735 Aero elasticity

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. INTRODUCTION

Definition and historical background, Static and dynamic aeroelastic phenomenon, Integration of aerodynamic, elastic and inertia forces, Influence of aeroelastic phenomenon on aircraft design, Comparison of critical speeds.

UNIT – II

2. DIVERGENCE OF LIFTING SURFACE

The phenomenon of divergence, divergence of 2-D wing section, divergence of an idealized cantilever wing, Solution based on semi-rigid assumptions, Solution in generalized co-ordinates, Method of successive approximation, use of Numerical Methods.

UNIT – III

3. STEADY STATE AERO-ELASTICITY PROBLEMS IN GENERAL

Loss and reversal of aileron Control, 2-D case, aileron reversal general case, Lift distribution on a rigid and elastic wing, Effect on Static Longitudinal stability of airplane.

4. INTRODUCTION TO FLUTTER AND BUFFETING

The phenomenon of flutter, flutter of a cantilever wing, Approximate determination of critical speed by Galerkin's Method, Introduction to buffeting and stall flutter.

UNIT – IV

5. **NON-AERONAUTICAL PROBLEMS**

Some typical example in civil engineering, Flow around an oscillating circular cylinder, applications to H-shaped sections, Prevention of aero-elastic instabilities.

Suggested Readings / Books:

1. An Introduction to the Theory of Aeroelasticity: Y.C. Fung, Dover Publications.
2. Aeroelasticity: R.L Bisplinghoff, Holt Ashley, R.L Halfman Addison –Wesley Publishing Co. Reading Mass.
3. Aircraft Structures for Engineering Students: T.H.C Megson, Elsevier.

BANE1-736 Airplane Design

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. PRELIMINARIES

Aircraft design, requirements and specifications, Airworthiness requirements. Weight: It's importance. Aerodynamic and structural design considerations. Classifications of airplane, Concept of configuration, Features of special purpose airplanes. Unmanned aerial vehicles and their features.

2. AIR LOADS IN FLIGHT

Classical methods of estimating symmetrical maneuvering loads on a wing in flight, Basic flight loading conditions, Load factor, V-n diagram, Gust loads, estimation of gust loads, Structural effects, Use of panel methods to estimate air load distribution on a wing.

UNIT – II

3. AIRPLANE WEIGHT ESTIMATION

Estimation of airplane weight based on airplane type/mission and material used, Trends in wing loading, Iterative approach.

4. WING DESIGN CONSIDERATIONS

Factors influencing selection of airfoil and plan form, Span wise air loads variation with span and planform, stalling, Take-off and landing considerations, BM and SF, Design principles for the structure of all metal, Stressed skin wing (Civil & Military airplane), Estimation of wing drag, Effect of flaps.

UNIT – III

5. STRUCTURAL LAYOUT AND INTEGRATION

Structural layout of straight, tapered swept (fwd and aft) wings. fuselage, empennage, Engine locations, Cockpit and passenger cabin layout, Layout of flight and engine controls, Wing-fuselage jointing methods, All metal airplane considerations, Use of composite materials. Preparation of 3-views, CG location.

6. LANDING GEARS

Requirement of landing gears, Different arrangements, mechanism for retraction into fuselage and wing, Absorption of landing loads, calculations of loads.

7. AIRFRAME POWER PLANT INTEGRATION

Estimation of horizontal and vertical tail volume ratios, Number of engines, Location for inlets and their considerations, Revised CG location.

UNIT – IV

8. MODERN CONCEPTS IN AIRPLANE DESIGN

Super critical wing, Relaxed stability, Control configured vehicles.

9. COMPLETE DESIGN PROBLEM

Preparation of conceptual design of an airplane from given specifications. Use and analysis of existing designs for this purpose. Design of airframe for the specifications, Prediction of performance, Stability and control, Selection of engines from all considerations with all details, Freezing the design, Preparation of preliminary drawings including 3 views and layout.

Suggested Readings / Books:

1. Airplane Design- A Conceptual Approach: Daniel P Raymer, AIAA Education Series USA.
2. The Design of Airplane : D.Stinton, GRANADA,UK.
3. Fundamentals of Aircraft Design : L.M.Nikolai, Univ. of Dayton Ohio.
4. Aerodynamics for Engineers : Bertin and Smith, Prentice Hall.

BANE1-737 Theory of Elasticity

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. 2-D PROBLEMS IN RECTANGULAR COORDINATES

Solution by polynomials, Bending of cantilever loaded at end, Bending of beam by uniform load, Symmetrical stress distribution.

2. 2-D PROBLEMS IN POLAR COORDINATES

Pure bending of curved bars, Strain components in polar coordinates, General equations in polar coordinates, Displacements for symmetrical stress distributions, Rotating disks, Bending of curved bar by a force at the end, Effect of circular holes on stress distribution in plates.

UNIT – II

3. PHOTOELASTICITY

Photoelastic stress measurement, Circular polariscope, Photoelastic stress determination, determination of principal stresses, 3-D photoelasticity.

UNIT – III

4. 3-D STRESS-STRAIN ANALYSIS

Introduction, Stress ellipsoid and stress-director surface, Determination of principal stresses, Stress invariants, Determination of maximum shearing stresses, Homogeneous deformation, Strain at a point, Principal axes of strain, Rotation.

5. 3-D PROBLEMS OF ELASTICITY

Uniform stress, Stretching of prismatic bar, Twist of circular shafts, Pure bending of prismatic bars and plates.

UNIT – IV

6. TORSION

Torsion of straight bars, elliptic cross section and other elementary solutions, Membrane analogy, Torsion of bar with narrow rectangular cross section, Torsion of rectangular bars, Torsion of rolled profile sections, Torsion of hollow shafts, Torsion of thin tubes, Torsion of circular shafts of variable diameter.

Suggested Readings / Books:

1. Theory of Elasticity: S.P.Timoshenko & J.N. Goodier, McGraw Hill.
2. Aircraft structures for Engineering Students: T H G Megson, Elsevier.
3. Theoretical Elasticity: A.E.H. Love

BANE1-756 Principles of Management and Professional Ethics

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. MANAGEMENT FUNCTIONS & STRUCTURE

Management – Definition, Basic Function, Contribution of Taylor & Fayol, Types of structure – Line, staff, Functional, Committee, Project & Matrix, Structures, Departmentalization, Centralization, Decentralization, span of control, Management by Objectives, Management by Exception.

UNIT – II

2. MANAGEMENT OF ORGANISATION

Forms of Business/Industrial Ownership, Sole Trader, Partnership, Company, Performance Appraisal, Basic Principles, Pitfalls, Methods to Overcome, Industrial Safety, Causes of Accidents, Cost of Accident, How to minimize Accidents, Plant Layout & Maintenance – Need, Types & Managerial Aspects.

UNIT – III

3. ORGANISATIONAL BEHAVIOUR

OB – Definition, Nature & Scope, Contributing Disciplines, Importance of OB to Managers, Personality – Definition, Theories, Factors Influencing Personality, Motivation – Definition, Theories, Theory X & Y, Transactional Analysis, Morale & Job Satisfaction, Factors Influencing Job Satisfaction.

4. GROUP DYNAMICS

Group – Definition, Types, Determinants of Group Cohesiveness, Communication, Process, Barriers, Effective Communication, Leadership Theories, Factors Contributing to Effective Leadership, Role of Trade Unions in Organizations, Functions of Trade Union, Why Trade Union is required? Types of Trade Unions.

UNIT – IV

5. PROFESSIONAL ETHICS

Ethics in Workplace, Formulation of Ethics, Managerial Ethics, Managing Ethical Behaviour, Codes of Ethics, Encouraging Ethical Behaviour, Social Responsibility, Spirituality.

Suggested Readings / Books:

1. Management Theory and Practice: C.B. Gupta, Sultan Chand & Sons.
2. Organisational Behaviour: Dr. L.M. Prasad, Sultan Chand & Sons.
3. Principle & Practice of Management: Dr. L.M. Prasad, Sultan Chand & Sons.
4. Organisational Behaviour: Aswathappa, Himalaya Publishing House.
5. Principles of Management: Harold Koontz, Tata McGraw Hill.

BANE1-757 Viscous Flow Theory

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. Outline of Fluid Motion with friction

Real and perfect fluid, Viscosity, Compressibility, The Hagen-Poiseuille flow through a pipe, Principle of Similarity: Reynolds and Mach number, Comparison between the theory of perfect fluids and experiments.

UNIT – II

2. Derivation of the equations of motion of a compressible viscous fluid (Navier-Stokes equations)

Fundamental equations of motion and continuity applied to fluid flow, General stress system in a deformable body, Relation between stress and rate of deformation, Stokes's hypothesis, Bulk viscosity and thermodynamic pressure, Navier-Stokes equations.

3. Outlines of Boundary-layer theory

The Boundary-Layer concept, Separation and vortex formation, Turbulent flow in a pipe and in a boundary layer.

UNIT – III

4. Laminar Boundary Layer Flows

Boundary layer Flow, Boundary Layer Equations, Approximate Momentum Integral Theory, Boundary Layers within accelerating potential flow, Flow over non-Slender Planner Bodies, Rotational Boundary Layers.

UNIT – IV

5. Boundary-layer equations for two-dimensional flow; Boundary-Layer on a flat plate

Derivation of boundary-layer equations for flow along a flat plate, The separation of a boundary layer, A Remark on the integration of the boundary layer equations, Skin friction, The boundary layer along a plate.

Suggested Readings / Books:

1. Boundary-Layer Theory: Dr Hermann Schlichting, McGraw-Hill Book Company.
2. Fluid Mechanics: Frank M White, McGraw-Hill Companies.
3. Physical Fluid Dynamics: P.D. McCormack and Lawrence Crane, Academic Press.

4. Viscous Flow Theory vol.I – Laminar Flow: Shih-i-Pai, P.Van Nostrand and Co.

BANE1-758 Air craft Maintenance and Air Transportation

L T P C **Duration – 45 Hrs.**
3 0 0 3

UNIT – I

1. AIR TRAFFIC CONTROL

Principles of Air Navigation and Air Traffic Control, Overview of CNS & ATM, Separation standards, Radar and Non-radar separation, Wake turbulence longitudinal separation minima, Precision approaches for landing, Radar systems for ATC.

UNIT – II

2. AIRLINES

Introduction to airline industry and economics, Determination of operating costs, Airline route selection and scheduling, Planning of flight operations, Special topics in airline operations, Emergence of LCC.

3. AIRPORTS

Aircraft characteristics affecting airport design, Airport layouts and configurations, Geometric design of the airfield, Wind Rose Diagram, Geometric design of the airfield.

UNIT – III

4. CURRENT ISSUES AND TRENDS IN AIR TRANSPORTATION

Modeling & Simulation of ATC systems, Estimation of airway Capacity & Delay, Human factors and Controller Workload, Performance based Navigation, Free Flight, Conflict Detection and resolution, Environmental effects of Aviation, Modeling air transport systems.

5. MAINTENANCE SCHEDULES

Maintenance of aircraft, its components, systems and sub-systems. Types of maintenance schedules, Mandatory schedules, Inspection of aircraft and components: Types of Inspections, Various Aircraft Manuals, Service Letters, Service Bulleting, Advisory Circulars, Repair, Modifications, Alteration, Reconditioning, History Record Sheet.

UNIT – IV

6. MAINTENANCE OF STRUCTURE AND VARIOUS SYSTEMS

Maintenance of aircraft structure, Propeller, Power-plant, Undercarriage, Hydraulic system, Fuel system, Air-conditioning system.

7. Aircraft Assembly and Rigging

Aircraft Assembly, Rigging, Alignment of fixed surfaces and flight controls systems in details, Balancing, Inspection and Maintenance. Flight control system of Helicopter.

Suggested Readings / Books:

1. Aircraft Maintenance and Repair : Kroes et.al, GLENCOE.
2. Fundamentals of Air Traffic Control : Michael S. Nolan, Thomson Brooks, Cole, USA.
3. Airline Route Planning : John H. H. Grover, BSP Professional Books, Blackwell Scientific Publications, Oxford, UK.
4. Air Transportation : A Management Perspective: John G. Wensveen, Ashgate Publishing, Ltd., UK.
5. Aircarft Basic Science : Kroes et.al, GLENCOE
6. An Introduction to Airline Economics : William E. O'Connor, Greenwood Publishing Group
7. Planning and Design of Airports : Robert Horonjeff & Francis X. McKelvey, Mcgraw Hill Professional Publishing.
8. Air Transportation Systems Engineering : George L. Donohue, Andres G. Zellweger, Editors, American Institute of Aeronautics and Astronautics.

8th Semester

BANE1-859 BOUNDARY LAYER THEORY

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. **Review of Basic Concepts and Formulation of Equation:** Descriptors/Topics: Boundary layer thickness, Momentum thickness, Energy thickness, Shape Factor, separation equations of Motion and energy equation for compressible viscous fluid-derivation and discussion, boundary layer equation and their general properties.

UNIT – II

2. **Exact and Approximate Methods and Axially Symmetrical Body:** Descriptors/Topics: Flat plate at zero incidence, Flows with pressure gradient, von Karman and Polhausen Methods. Rotation near ground, Circular jet, Boundary layer on a body of revolution, flow in the entrance section of pipe.

UNIT – III

3. **Thermal Boundary Layer, Transition and Boundary Layer Control:** Descriptors/Topics: Heat transfer from heated surface. Incompressible and compressible laminar flow over a flat plate, Plate thermometer problem. Pipe flow and flow over a flat plate, Critical Reynolds number, Turbulent spots, Principles of theory of stability of Laminar flows, Sommer-field equation, factors affecting transition, Laminar airfoils.

   Methods of control, Fundamental equations and exact solution for a flat plate with uniform suction, Compressible Boundary Layers with suction, Approximate solution for a flat plate with uniform suction, compressible boundary layers with suction approximate solutions, theoretical and experimental results.

UNIT – IV

4. Turbulent Boundary Layer and pipe flows: Descriptors/Topics: Fundamentals of Turbulent flow, Mean motion and fluctuations, Reynolds, stresses, wind tunnel Turbulence, Prandtls mixing Length theory, Von Karman's similarity Hypothesis, Velocity distribution laws. Experimental results through smooth pipes, Relation between laws of friction and velocity distribution, Universal Resistance law for smooth pipe at large Reynolds number, Rough pipe and equivalent roughness.

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RECOMMENDED BOOKS

3. John D. Anderson (Jr.), 'Fundamentals of Aerodynamics', 2nd Edition., McGraw Hill.
4. Gupta and Gupta, 'Fluid Mechanics and its Applications', Wiley Eastern, **1960**
5. H. Schlichting, 'Boundary Layer Theory', 6th Edition., McGraw Hill, **1986.**

6. Frank M. White, 'Fluid Mechanics', 2nd Edition, McGraw Hill, **1986.**

BANE1-860 ADVANCED AERODYNAMICS

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. Elements of compressible flow: Compressible flow properties: Total Enthalpy, Total Temperature, Temperature and Pressure ratios as a function of Mach No., Mass Flow Parameter (MFP). Isentropic Area ratio (A/A*), Velocity-Area variations, Rayleigh Pitot tube formula, Flow in constant area duct with friction and heat transfer.

UNIT – II

2. Non-Linear Supersonic Flows: Numerical techniques, method of characteristics, supersonic nozzle design, finite difference method, time dependent technique for supersonic blunt bodies, numerical problems. Compressibility effects of aerodynamic characteristics of lift generating surfaces

UNIT – III

3. **Supersonic Analysis for configurations:** Governing equations and boundary conditions, consequences of linearity, conical flow method for rectangular, swept, delta and arrow wings, singularity distribution method, design nsideration for supersonic aircraft, aerodynamic interaction, supersonic analysis for complete configurations.

UNIT – IV

4. **Supersonic Lift Theory and Hypersonic flow:** Shock –Expansion theory, flow field in supersonic flows, numerical problems, thin airfoil theory, analytical determination of lift and drag coefficients on flat plate, bi-convex, and diamond shaped sections in supersonic flows, numerical problems, supersonic leading and trailing edges. Qualitative aspects, Newtonian theory, lift and drag of wings at hypersonic speeds, hypersonic shock wave relations, Mach no. independence, hypersonic and CFD, high L/D hypersonic configurations, Aerodynamic heating, ground test data and flight test data.

INSTRUCTIONAL STRATEGY

Visual aids like videos and presentations must be used in order to explain theoretical concepts in a better way, where applicable.

RECOMMENDED BOOKS

1. "Modern Compressible Flow with Historical Perspective", Anderson, J. D., 3rd edition., McGraw-Hill
2. "Aerodynamics", L.J.Clancy, 5th Ed. Himalayan Books
3. "Aerodynamics for Engineers", John J Bertin, 4th Ed, Pearson Publishers

4. "Gas Dynamics", Vol I , Zucrow, M J and J D Hoffman, John Wiley & sons
5. "Gas Dynamics (Fifth Edition)", Dr. E. Rathakrishnan, PHI Learning, Delhi, India, 2013.

BANE1-861 EXPERIMENTAL AERODYNAMICS

L T P C **Duration – 60 Hrs.**
3 1 0 4

UNIT – I

1. Introduction: Types of wind tunnels – Open and closed wind tunnels; wind tunnels with open and closed test sections; variable density wind tunnels; smoke tunnels; vertical wind tunnels; sub-sonic, super-sonic, trans-sonic wind tunnel; water tunnels. Wind tunnel calibration, Measurements techniques in wind tunnels: forces and moments, pressure, velocity, temperature, aero-acoustic measurements.

UNIT – II

2. Qualitative and Quantitative Measurements: Low speed flow visualization techniques, Schlieren, shadowgraph, interferometry, introduction to laser diagnostic techniques.

Measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals, Steady and unsteady pressure measurements and various types of pressure probes and transducers, errors in pressure measurements, thermocouples, thermography, velocity measurement using hot wire anemometry, Laser Doppler Velocimetry and Particle Image Velocimetry

UNIT – III

3. Data Acquisition and Processing: Data acquisition and digital signal processing techniques, wind tunnel data acquisition, measurement of steady and unsteady pressure, velocity, temperature, turbulence intensity, calibration of force, pressure and acoustic sensors. Calibration of single and two wire probes.

Data validation techniques: verifying experimental data with theoretical and computational results.

UNIT – IV

4. Virtual Instrumentation: Introduction to VI (virtual instrumentation) and its typical applications, functional systems, graphical programming, data flow techniques, advantages of VI techniques. VI programming techniques; VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, string and file I/O, DAQ methods, code interface nodes.

INSTRUCTIONAL STRATEGY

In case of data acquisition and analysis, hands on experience in instruments and computational facilities should supplement classroom teaching.

RECOMMENDED BOOKS

- "Low speed wind tunnel testing", Jewel B. Barlow, John Wiley & sons
- "Experimental Aerodynamics", Henry Christensen, Pavian,Pitman Publishing
- "Wind Tunnels: Aerodynamics, Models & Experiments (Engineering Tools, Techniques and Tables)", Justin D. Pereira.
- "Virtual instrumentation using LabVIEW", Jerome Jovitha, PHI Learning Private Ltd.

RECOMMENDED BOOKS

1. "Modern Compressible Flow with Historical Perspective", Anderson, J. D., 3rd edition., McGraw-Hill
2. "Aerodynamics", L.J.Clancy, 5th Ed. Himalayan Books
3. "Aerodynamics for Engineers", John J Bertin, 4th Ed, Pearson Publishers
4. "Gas Dynamics", Vol I , Zucrow, M J and J D Hoffman, John Wiley & sons
5. "Gas Dynamics (Fifth Edition)", Dr. E. Rathakrishnan, PHI Learning, Delhi, India, 2013.

Open Elective-I

Open Elective-II

BANE1- 840 Project-II