# Aeronautical Engineering (AN)

## EN010301A ENGINEERING MATHEMATICS II
## (Common to all branches except CS & IT)

**Teaching scheme** **Credits: 4**

2 hours lecture and 2 hour tutorial per week

**Objectives**

- *To apply standard methods and basic numerical techniques for solving problems and to know the importance of learning theories in Mathematics.*

**MODULE 1** Vector differential calculus ( 12 hours)

Scalar and vector fields – gradient-physical meaning- directional derivative-divergence an curl - physical meaning-scalar potential conservative field-identities - simple problems

**MODULE 2** Vector integral calculus ( 12 hours)

Line integral - work done by a force along a path-surface and volume integral-application of Greens theorem, Stokes theorem and Gauss divergence theorem

**MODULE 3** Finite differences ( 12 hours)

Finite difference operators $\Delta, \nabla, E, \mu$ and $\delta$ - interpolation using Newtons forward and backward formula – problems using Stirlings formula, Lagrange's formula and Newton's divided difference formula

**MODULE 4** Difference Calculus ( 12 hours)

Numerical differentiation using Newtons forward and backward formula – Numerical integration – Newton's – cotes formula – Trapezoidal rule – Simpsons $1/3^{rd}$ and $3/8^{th}$ rule – Difference equations – solution of difference equation

**MODULE 5** **Z** transforms ( 12 hours)

Definition of Z transforms – transform of polynomial function and trignometric functions – shifting property , convolution property - inverse transformation – solution of $1^{st}$ and $2^{nd}$ order difference equations with constant coifficients using Z transforms.



**Reference**


1. Erwin Kreyszing – Advance Engg. Mathematics – Wiley Eastern Ltd.
2. B.S. Grewal – Higher Engg. Mathematics - Khanna Publishers
3. B.V. Ramana - Higher Engg. Mathematics – McGraw Hill
4. K Venkataraman- Numerical methods in science and Engg -National publishing co
5. S.S Sastry - Introductory methods of Numerical Analysis -PHI
6. T.Veerarajan and T.Ramachandran- Numerical Methods- McGraw Hill
7. Babu Ram – Engg. Mathematics -Pearson.
8. H.C.Taneja Advanced Engg. Mathematics Vol I – I.K.International

## EN010 302 Economics and Communication Skills

(Common to all branches)

**Teaching scheme**
**2hours lecture and 2 hours tutorial per week** **Credits: 4(3+1)**

**Objectives**

- To impart a sound knowledge of the fundamentals of Economics.

## Economics

**Module I** (7 hours)
Reserve Bank of India-functions-credit control-quantitative and qualitative techniques
Commercial banks-functions- Role of Small Industries Development Bank of India and National Bank for Agriculture and Rural Development
The stock market-functions-problems faced by the stock market in India-mutual funds

**Module II** (6 hours)
Multinational corporations in India-impact of MNC's in the Indian economy
Globalisation-necessity-consequences
Privatisation-reasons-disinvestment of public sector undertakings
The information technology industry in India-future prospects

**Module III** (6 hours)
Direct and indirect taxes- impact and incidence- merits of direct and indirect taxes-progressive and regressive taxes-canons of taxation-functions of tax system-
tax evasion-reasons for tax evasion in India-consequences-steps to control tax evasion
Deficit financing-role-problems associated with deficit financing

**Module IV** (5 hours)
National income-concepts-GNP, NNP, NI, PI and DPI-methods of estimating national income-difficulties in estimating national income
Inflation-demand pull and cost push-effects of inflation-government measures to control inflation

**Module V** (6 hours)
International trade-case for free trade-case for protectionism
Balance of payments-causes of disequilibrium in India's BOP-General Agreement on Tariffs and Trade-effect of TRIPS and TRIMS in the Indian economy-impact of WTO decisions on Indian industry

**Text Books**

1. Ruddar Datt, Indian Economy, S.Chand and Company Ltd.
2. K.K.Dewett, Modern Economic Theory, S.Chand and Company Ltd.

**References**

1. Paul Samuelson, Economics, Tata McGraw Hill
2. Terence Byres, The Indian Economy, Oxford University Press
3. S.K.Ray, The Indian economy, Prentice Hall of India
4. Campbell McConnel, Economics, Tata McGraw Hill

## Communication Skills

**Objectives**

- To improve Language Proficiency of the Engineering students
- To enable them to express themselves fluently and appropriately in social and professional contexts
- To equip them with the components of different forms of writing

**MODULE – 1 (15 hours)**

INTRODUCTION TO COMMUNICATION

Communication nature and process, Types of communication - Verbal and Non verbal, Communication Flow-Upward, Downward and Horizontal, Importance of communication skills in society, Listening skills, Reading comprehension, Presentation Techniques, Group Discussion, Interview skills, Soft skills

**MODULE – II (15 hours)**

TECHNICAL COMMUNICATION

Technical writing skills- Vocabulary enhancement-synonyms, Word Formation-suffix, affix, prefix, Business letters, Emails, Job Application, Curriculum Vitae, Report writing- Types of reports

**Note: No university examination for communication skills. There will be internal evaluation for 1 credit.**

**REFERENCES**

1. The functional aspects of communication skills, P.Prasad and Rajendra K. Sharma, S.K. Kataria and sons, 2007
2. Communication skills for Engineers and Scientists, Sangeeta Sharma and Binod Mishra, PHI Learning private limited, 2010
3. Professional Communication, Kumkum Bhardwaj, I.K. International (P) House limited, 2008
4. English for technical Communication, Aysha Viswamohan, Tata Mc Graw Publishing company limited, 2008

# AN010 303: Fluid Mechanics

(Common with ME010 303 and PE010 303)

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To impart the basic concepts of fluid mechanics by providing exposure to diverse real world engineering examples.*
- *To develop understanding about basic laws and equations used for analysis of static and dynamic fluids.*

**Module I (15 hours)**

Introduction and basic concepts-properties of fluids-density, specific gravity, specific weight, specific volume, capillarity, surface tension, compressibility, bulk modulus, viscosity-Newtonian and non Newtonian fluids.

Fluid statics: pressure-variation of pressure-absolute and guage pressure- Pascal's law, manometers- hydrostatic force on plane and curved surfaces-buoyancy and floatation-stability of submerged and floating bodies-metacentric height.

**Module II (12 hours)**

Euler's momentum equation-Bernoulli's equation and its limitations-momentum and energy correction factors-applications of Bernoulli's equation-venturimeter, orifice meter, pitot tube, orifices and mouthpieces, notches and weirs-rotameter.

**Module III (10 hours)**

Flow through pipes-laminar and turbulent flow in pipes-critical Reynolds number- Darcy Weisbach equation-hydraulic radius-power transmission through pipes-losses in pipes-pipes in series pipes in parallel-hydraulic gradient line and total energy line-equivalent pipe--moody's diagram-water hammer.

Open channel flow-Chezy's equation-most economical cross section-hydraulic jump.

**Module IV (12 hours)**

Fluid kinematics-Eulerian and Lagrangian approaches-classification of fluid flow-graphical description of flow pattern-stream lines, path lines, streak lines, stream tubes-velocity and acceleration in fluid flow-continuity equation.

Ideal fluids-rotational and irrotational flow-circulation and vorticity-potential function and stream function, basic flow fields-uniform flow. Source, sink, doublet, vortex, spiral flow, flow past a cylinder with circulation-Magnus effect-Joukowski theorem.

**Module V (11 hours)**

Boundary layer-boundary layer flow theory- boundary layer over flat plate- boundary layer thickness-displacement, momentum and energy thickness-boundary layer separation-methods of controlling-wake-drag force on a rectangular plate-pressure drag-friction drag-total drag-streamlined body-bluff body, lift and drag force on an aerofoil-characteristics-work done. Hagen-Poiseuille equation.

**Text Books**

1. Yunus A. Cengel and John M. Cimbala, *Fluid Mechanics*, Tata McGraw Hill, New Delhi
2. R.K.Rajput, *Fluid Mechanics*, S Chand and Company, New Delhi

**Reference Books**

1. Douglas, *Fluid Mechanics*, Pearson Education, New Delhi
2. Shames I.H, *Fluid Mechanics*, Tata McGraw Hill, New Delhi
3. D. S .Kumar , *Fluid Mechanics*, S. K. Kataria & Sons, New Delhi
4. White F.M, *Fluid Mechanics*, Tata McGraw Hill, New Delhi
5. S. K. Som & G Biswas, *Fluid Mechanics*, Tata McGraw Hill, New Delhi
6. R. K. Bhansal, *Fluid Mechanics& Hydraulic Machines*, Laxmi Publications, New Delhi
7. B.S Massey, *Fluid Mechanics*, Tata McGraw Hill, New Delhi
8. Mody & Seth, *Fluid Mechanics& Hydraulic Machines*, Laxmi Publications, New Delhi
9. F.M. Streeter, *Fluid Mechanics*, Tata McGraw Hill, New Delhi
10. Jagdishlal , *Fluid Mechanics & Hydraulics*, Metropolitan Book Co., New Delhi

# AN010 304: Basic Thermodynamics

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To impart the basic concepts of Thermodynamics*

**Module I (---8---hours)**
Fundamentals concepts – scope and limitations of thermodynamics. Thermodynamic systems – different types of systems – macroscopic and microscopic analysis – continuum – Properties – state – processes. Thermodynamics equilibrium – Equation of state of an ideal gas – PVT system – Real gas relations – Compressibility factor – Law of corresponding states.

**Module II (---15---hours)**
Las of thermodynamics- Zeroth law of thermodynamics – Thermal equilibrium – Concept of temperature – Temperature scales – Thermometry – Perfect gas temperature scales. – Thermometry – Perfect gas temperature scales. Work and heat – First law of thermodynamics – Concept of energy _ First law for closed and open systems – Specific heats – internal energy and enthalpy – Steady flow energy equations _ Jule Thompson effect.

**Module III (---15---hours)**
Second law of thermodynamics- Various statements and their equivalence_ Reversible process and reversible cycles- Carnot cycles- Corollaries of the second law – thermodynamics temperature scales – Clausis inequality- Concept of entropy – Calculation of change in entropy in various thermodynamic processes – Reversibility and irreversibility – Available and unavailable energy – Third law of thermodynamics.

**Module IV (--11--- hours)**
Thermodynamic relations – Combined first and second law equations – Hemholtz and gibbs functions – Maxwell relations- Equations for specific heats, internal energy, enthalpy and entropy – Clausius Clapeyron equations _ applications of thermo dynamic relations.

**Module V (----11-- hours)**
Properties of pure substances – PVT, PT and TS diagrams, Mollier diagrams- Mixture of gases and vapours- mixture of ideal gases – Dalton's law – Gibbs law- Thermodynamic properties of mixtures



**Text Books**

1 P K Nag, *Engineering Thermodynamics*, Tata Mc Graw Hill Publishing Company Ltd. New Delhi 2008.

**Reference Books**

1. J. F. Lee and FW Sears, *Engineering Thermodynamics,* Addison-Wesleg Publishing Company, London, 1962.
2. Spalding and Cole, *Engineering Thermodynamics,* The English Language Book Society and Edward Arnold Ltd.,1976.
3. M. A.chuthan, *Engineering Thermodynamics,*Prentice Hall of India Private Ltd, New Delhi 2002.
4. J.H Keenan, *Thermodynamics,* John Wiley and Sons , New York, 1963.
5. Edward F Obert, *Concept of Thermodynamics,* McGraw Hill book company New York, 1988.
6. J.P. Holman, *Thermodynamics,* McGraw Hill book company New York, 1988.
7. Mark W. Zemansky, *Heat and Thermodynamic,* McGraw Hill, New Delhi, 2001.
8 Roy T, *Basic Engineering Thermodynamics,* Tata Mc Graw Hill Publishing Company Ltd. New Delhi 1989.

## AN010 305: Elements of Aeronautics

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To introduce the basic concepts of aerospace engineering and the current developments in the related fields*

**Module I (10 hours)**
Historical evaluation
Early airplanes, biplanes and monoplanes, Developments in aerodynamics, materials, structures and propulsion over years.

**Module II (12 hours)**
Aircraft configurations
Components of an airplane and their functions. Different types of flight vehicles, classifications. Conventional control, Powered control, Basic instruments for flying, typical systems for control actuation.

**Module III (12 hours)**
Introduction to principles of flight
Physical properties and structure of the atmosphere, Temperature, pressure and altitude relationships, Evolution of lift, drag and moment. Aerofoils, Mach number, Maneuvers.

**Module IV (12 hours)**

Introduction to airplane structures and materials
General types of construction, Monocoque, semi-monocoque and geodesic construction, Typical wing and fuselage structure. Metallic and non-metallic materials, Use of aluminum alloy, titanium, stainless steel and composite materials.

**Module V ( 12hours)**
Power plants used in airplanes
Basic ideas about piston, turboprop and jet engines, Use of propeller and jets for thrust production. Comparative merits, Principles of operation of rocket, types of rockets and typical applications, Exploration into space.

**Text Books**

I. Anderson, J.D., "Introduction to Flight", McGraw-Hi II, 1995.

**Reference**

*Kermode, A.c., "Flight without Formulae", McGraw Hill, 1997*

# AN010 306: Basic Strength of Materials

**Teaching scheme** **Credits: 4**
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To study internal effects produced and deformations of bodies caused by externally applied forces.*
- *To understand the stresses and strains in different materials and analyse strength characteristic of structural members.*

**Module I (15 hours)**
Introduction to analysis of deformable bodies:-
stresses due to normal, shear and bearing loads-Axial and shear strains –
Simple stresses and strains: Material behavior - uniaxial tension test - stress-strain diagrams. Hooke's law for linearly elastic isotropic material.
Elastic constants - relation between them - Bars of varying cross section -Composite sections- Equilibrium and compatibility conditions- Temperature stresses

**Module II (10 hours)**
Bending moment and shear force: Cantilever, simply supported and overhanging beams - concentrated and U.D loading (analytical method) Relation between load shear force and bending moment.

**Module III (15 hours)**
Stresses in beams: Pure bending - flexure formula for beams - assumptions and limitations -section modulus - flexural rigidity - economic sections beams of uniform strength. Shearing stress formula for beams - assumptions and limitations.
Deflection of beams: Moment-curvature relation - assumptions and limitations singularity functions - Macaulays method - moment area method for simple cases.

**Module IV (10 hours)**
Torsion: Torsion theory of elastic circular bars – solid and hollow shaft assumptions and limitations - polar modulus- torsional rigidity - economic cross-sections.
Pressure vessels: Thin and thick cylinders-Lame's equation-stresses in thick cylinders due to internal pressure – compound pipes.

**Module V (10 hours)**
Combined stresses: Principal stresses and planes-Mohr's circle representation of stress in 2D problems. Use of strain gage rosettes. Combined axial, flexural and torsional loads.
Theory of columns: Buckling theory -Euler's formula for long columns - assumptions and limitations - effect of end conditions - slenderness ratio - Rankine's formula for intermediate columns -Eccentric loading of columns - kern of a section (rectangular and circular section).

**Text Books**

3. Timoshenko.S.P, Strength of Materials, Part 1,D.Van Nostrand company, Inc.Newyork.
4. Bansal R.K., Strength of Materials, Lakshmi Publications, New Delhi.
5. Mott, Robert L, Applied strength of materials, 5th Edn, Prentice Hall of India.
6. Popov E.P., Engineering Mechanics of solids, Prentice Hall of India, New Delhi.

**Reference Books**

1. Nash.W.A , Strength of Materials, Schaum's Outlines,Sth Edn, TMH
2. Gere, James M , Mechanics of Materials, Cengage Learning.
3. Shames IH , Pitarresi, James.M, Introduction to Solid Mechanics, Prentice Hall of India.

## AN010 307: Basic Strength of Materials Lab

**Teaching scheme** **Credits:** 2
3 hours practical per week

**List of Experiments**

1. Hardness test (Brinell, Vicker's and Rebound)
2. Verification of Clerk. Maxwell's Law of reciprocal deflection and Determination of Youngs modulus'E 'for steel.
3. Shear Test on M.S. Rod.
4. Tension test using U. T. M. on M. S. Rod, torsteel and High Tensile steel.
5. Torsion test on mild steel rod
6. Impact test on metal specimen (a) Izad (b) Charpy
7. Fatigue test (a) Reverse plate bending (b) Rotating beam
8. Tests on springs (open and close coiled).
9. Block compression test.
10. Deflection test on beams
11. Strain Measurement using Rosette strain gauge



**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

# AN010 308: Fluid Mechanics Lab

(Common with ME010 308, PE010 308 and AU010 308)

**Teaching scheme** **Credits:** 2

3 hours practical per week

**Objectives**

- *To provide exposure to the actual flow process and various instruments adopted for flow measurement .*

- Study and acquire a thorough knowledge of the various pipe fittings and plumbing tools.
- Study the use of different types of taps, valves.
- Study the various measuring instruments like gauges, pitot tube, watermeters and current meters.
- Determination of metacentric height and radius of gyration of floating bodies.
- Determination of hydraulic coefficients of orifices and mouthpieces under constant head method and time of emptying method.
- Calibration of discharge measuring equipments in closed conduits like venturimeter, orificemeter, watermeter etc.
- Calibration of discharge measuring equipments in open channel flow like rectangular and triangular notches.
- Determination of Darcy's constant and Chezy's constant for pipe flow.
- Determination of critical velocity in pipe flow.
- Determination of minor losses in pipe flow.
- Experimental verification of Bernoulli's theorem.
- Determination of Chezy's constant and Manning's number for open channel flow.
- Calibration of Plug –Sluices.



**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

## EN010401 Engineering Mathematics III

(Common to all branches)

**Teaching scheme** **Credits: 4**

2 hours lecture and 2 hour tutorial per week

**Objectives:** *Apply standard methods of mathematical &statistical analysis*

**MODULE 1** Fourier series ( 12 hours)

Dirichlet conditions – Fourier series with period 2 π and 2l – Half range sine and cosine series – Harmonic Analysis – r.m.s Value

**MODULE 2** Fourier Transform ( 12 hours)

Statement of Fourier integral theorem – Fourier transforms – derivative of transforms- convolution theorem (no proof) – Parsevals identity

**MODULE 3** Partial differential equations ( 12 hours)

Formation by eliminating arbitrary constants and arbitrary functions – solution of Lagrange's equation – Charpits method –solution of Homogeneous partial differential equations with constant coefficients

**MODULE 4** Probability distribution ( 12 hours)

Concept of random variable , probability distribution – Bernoulli's trial – Discrete distribution – Binomial distribution – its mean and variance- fitting of Binominal distribution – Poisson distribution as a limiting case of Binominal distribution – its mean and variance – fitting of Poisson distribution – continuous distribution- Uniform distribution – exponential distribution – its mean and variance – Normal distribution – Standard normal curve- its properties

**MODULE 5** Testing of hypothesis ( 12 hours)

Populations and Samples – Hypothesis – level of significance – type I and type II error – Large samples tests – test of significance for single proportion, difference of proportion, single mean, difference of mean – chi –square test for variance- F test for equality of variances for small samples

**References**


1. Bali& Iyengar – A text books of Engg. Mathematics – Laxmi Publications Ltd.
2. M.K. Venkataraman – Engg. Mathematics vol II 3rd year part A & B – National Publishing Co.
3. I.N. Sneddon – Elements of partial differential equations – Mc Graw Hill
4. B.V. Ramana – Higher Engg. Mathematics – Mc Graw Hill
5. Richard A Johnson – Miller Fread's probability & Statistics for Engineers- Pearson/ PHI
6. T. Veerarajan – Engg. Mathematics – Mc Graw Hill
7. G. Haribaskaran – Probability, Queueing theory and reliability Engg. – Laxmi Publications
8. V. Sundarapandian - probability ,Statistics and Queueing theory – PHI
9. H.C.Taneja – Advanced Engg. Mathematics Vol II – I.K.International
10. A.K.Mukhopadhyay-Mathematical Methods For Engineers and Physicists- I.K.International
11. H.C.Taneja – Advanced Engg. Mathematics Vol II – I.K.International
12. A.K.Mukhopadhyay-Mathematical Methods For Engineers and Physicists-I.K.International

# AN010 402: Gas Dynamics

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To understand the basics and concepts of gas dynamics*

**Module I (12 hours)**
Thermodynamics of gas flow.
Introductory concepts of compressible flow, Isentropic flow, Stagnation properties, Sonic velocity, Isentropic flow of vapours and ideal gases through nozzles and diffusers, Super saturation in nozzles, Irreversible adiabatic flow through nozzles.

**Module II (12 hours)**
Effect of normal shock on gas flow.
Normal shocks, Stationary and moving applications, applications to supersonic wind tunnels, Shock tubes, Supersonic pitot probes.

**Module III (12 hours)**
Effect of oblique shocks.
Oblique shock, Reflection, Prandtl Meyer expansion flow, Fanno flow, and Raleigh flow under and over expanded nozzles, Shock expansion method for flow over airfoils.

**Module IV (12 hours)**
Airfoil theory.
Prandtl, Glauert and Goethert rules, Aukerets supersonic airfoil theory

**Module V (12 hours)**
Perturbation equations in Compressible flow.
Small perturbation equations for subsonic, Transonic, Supersonic and hypersonic flow, Experimental characteristics of air foils in compressible flow.



**Text Books**

**Reference Books**

1. Anderson Jr. D, Fundamentals of Aerodynamics, Mc grow Hill
2. P. Balachandran , Gas Dynamics For Engineers, PHI Learning.
3. Robert D. Zucker and Oscar Biblarz, Fundamentals of Gas Dynamics, Second Edition, John Wiley & Sons, Inc.
4. E. Rathakrishnan, Gas Dynamics, PHI Private Ltd, 2003.

# AN010 403: Propulsion I

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

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

**Module I (12 hours)**

Fundamentals of gas turbine engines

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

**Module II (12 hours)**

Subsonic and supersonic inlets for jet engines

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

**Module III (12 hours)**

Combustion chambers

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

**Module IV (12 hours)**

Nozzles

Theory of flow in isentropic nozzles - Convergent nozzles and nozzle choking - Nozzle throat conditions, Nozzle efficiency - Losses in nozzles - Over expanded and under - expanded nozzles - Ejector and variable area nozzles - Interaction of nozzle flow with adjacent surfaces - Thrust reversal

**Module V (12 hours)**

Compressors

Principle of operation of centrifugal compressor - Work done and pressure rise - Velocity diagrams - Diffuser vane design considerations - Concept of prewhirl - Rotation stall - Elementary theory of axial flow compressor - Velocity triangles - degree of reaction – Three dimensional flow- Air angle distributions for free vortex and constant reaction designs - Compressor blade design - Centrifugal and Axial compressor performance characteristics.

**Text Books**

Hill, P.G. & Peterson. C.R. "Mechanics & Thermodynamics of Propulsion" Addison - Wesley Longman INC. 1999.

**Reference Books**

1. Cohen, H. Rogers, G.F.e. and Saravanamuttoo, H.I.H. "Gas Turbine Theory", Longman, 1989.
2. Oates, G.e., "Aero thermodynamics of Aircraft Engine Components", AIAA Education Series, New York, 1985.
3. "Rolls Royce Jet Engine" -Third Edition -1983.
Mathur, M.L. and Sharma, R.P., "Gas Turbine, Jet and Rocket Propulsion", Standard Publishers & Distributors. Delhi, 1999.

# AN010 404: Aerodynamics I

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

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

**Module I (10 hours)**
Fluid mechanics fundamentals
Continuity, momentum and energy equations.

**Module II (12 hours)**
Two dimensional flows
Basic flows -Source, Sink, Free and Forced vortex, uniform parallel flow. Their combinations, Pressure and velocity distributions on bodies with and without circulation in ideal and real fluid flows. Kutta Joukowski's theorem.

**Module III (12 hours)**
Conformal transformation
Joukowski Transformation and its application to fluid flow problems, Kutta condition, Blasius theorem.

**Module IV (14 hours)**
Airfoil and wing theory
Joukowski, Karman -Trefftz, Profiles -Thin aerofoil theory and its applications. Vortex line, Horse shoe vortex, Biot and Savart law, Lifting line theory and its limitations. viscous flow:Newton's law of viscosity, Boundary Layer, Navier-Stokes equation, displacement, Momentum thickness, Flow over a flat plate, Blasins solution.

**Module V (12 hours)**
Viscous flow
Newton's law of viscosity, Boundary Layer, Navier-Stokes equation, displacement, Momentum thickness, Flow over a flat plate, Blasin solution.



**Text Books**

1. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw-Hill Book Co., New York, 1985

**Reference Books**

1. Houghton, E.L., and Carruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 1989.
2. Milne Thomson, L.H., "Theoretical aerodynamics", Macmillan, 1985.
3. Clancey, L.J., "Aerodynamics", Pitman, 1986

# AN010 405: Aircraft Structures I

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**
*To study different types of beams and columns subjected to various types of load and supports with emphasis on aircraft structural components.*

**Module I (12 hours)**
Statically determinate structures
Double integration and moment area methods, Conjugate beam method, Principle of superposition, Beams of constant strength, Analysis of plane truss - Method of joints - 3 D Truss - Plane frames

**Module II (10 hours)**
Statically indeterminate structures
Composite beam - Clapeyron's Three Moment Equation - Moment Distribution Method.

**Module III (12 hours)**
Energy methods
Strain Energy due to axial, shear, bending and Torsional loads - Castigliano's theorem - Maxwell's Reciprocal theorem, Unit load method - application to beams, trusses, frames, rings, etc.

**Module IV (12 hours)**
Columns
Columns with various end conditions - Euler's Column curve - Rankine's formula - Column with initial curvature - Eccentric loading - South well plot - Beam column.

**Module V (14 hours)**
Theories of failure
Maximum Stress theory - Maximum Strain Theory - Maximum Shear Stress Theory- Distortion Theory Maximum Strain energy theory - Application to aircraft Structural problems.

**Text Books**
Donaldson, B.K., "Analysis of Aircraft Structures -An Introduction", McGraw-Hill, 1993.

**Reference**
Timoshenko, S., "Strength of Materials", Vol. I and II, Princeton D. Von Nostrand Co, 1990.

# AN010 406: Electrical Technology and Machines

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

## Objective

- *To study the performance of different dc and ac machines*
- *To familiarise various electrical measuring instruments*
- *To give an overview of electric drives and power electronic control scheme*

**Module I (12hours)**

Review of DC generators – DC generator on no load – open circuit characteristics – basics of armature reaction and commutation – load characteristics of shunt, series and compound generators – Review of dc motors – characteristics of shunt, series and compound motors – starter – 3 point and 4 point starters – losses in DC machines – power flow diagram – efficiency – applications of DC motors.

**Module II (12 hours)**

Review of transformers – Real transformer – winding resistance and leakage reactance – equivalent circuit – phasor diagram – voltage regulation – losses and efficiency – open circuit and short circuit test – Autotransformer – saving of copper – 3 phase transformer - Δ-Δ, Y-Y, Δ - Y, Y - Δ connections – applications. Principle of indicating instruments – moving coil, moving iron and dynamometer type instruments – extension of range of ammeter and voltmeter using current transformer and voltage transformer – principle and working of induction type energy meter

**Module III (16hours)**

Review of alternators – distribution and chording factor – EMF equation – armature reaction – phasor diagram – voltage regulation – predetermination of voltage regulation by EMF method.

Review of 3-phase induction motor – slip – rotor frequency – equivalent circuit – phasor diagram – torque equation – torque-slip characteristics – losses and efficiency – power flow diagram – no-load and blocked rotor tests – starting of 3-phase induction motors – direct-on-line, auto transformer, star-delta and rotor resistance starting.

**Module IV (10 hours)**

Electrical Drives - Parts of electrical drives - Choice of electric drives - Status of DC and AC drives - Dynamics of Electric drives - Fundamental torque equations – Speed torque conventions and multiquadrant operation - Components of load torque - Nature and classification of load torque - Steady-state stability – load equalisation.

**Module V (10 hours)**

Power semiconductor devices - Symbol and control characteristics of SCR – comparison of SCR, TRIAC, MOSFET and IGBT – Basic concepts of Rectifier (AC-DC) , Inverter (DC-AC ) and Choppers (DC-DC) (no derivations) - Chopper control of separately excited dc motor - Three phase Induction motor drives - Stator voltage control - Frequency control - Voltage and frequency control

**Text Books**

1. Vincent Del Toro, *Electrical Engineering Fundamentals*, Prentice-Hall of India
2. Hughes, *Electrical technology*, Tata Mc Graw Hill
3. Dubey G.K., *Fundamentals a/Electrical Drives,* Narosa

**Reference Books**

1. K. Sawhney, Electrical and Electronics measuring Instruments, Dhanpat Rai & Sons.
2. P.S. Bhimbra, Electrical Machinery, Khanna Publishers
3. K. Murukesh Kumar, DC machines and Transformers, Vikas Publishing house Pvt Ltd
4. Rashid M.H, Power Electronics, Prentice Hall of India

## AN010 407: Structures Lab

**Teaching scheme** **Credits:** 2
3 hours practical per week

**Objectives**
*To study experimentally the load deflection characteristics of structural materials under different types of loads.*

**List of experiments**

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

| Sl No. | Equipments | Qty | Experiment No. |
|---|---|---|---|
| 1 | Universal Testing Machine | 1 | 1,2,3,4,5,10 |
| 2 | Mechanical Extensometer | 1 | 1 |
| 3 | Electrical Strain Gauge | 10 | 2 |
| 4 | Strain Indicator | 1 | 2 |
| 5 | Dial Gauges | 12 | 3,4 |
| 6 | Beam test set up with various end conditions | 2 | 3,4 |
| 7 | Weight 1kg | 10 | 3,4 |
| 8 | Weight 2kg | 10 | 3,4 |
| 9 | Weight Pans | 6 | 3,4 |
| 10 | Column test apparatus | 1 | 5,6 |
| 11 | Rivets | 30 | 10 |

**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

# AN010 408: Propulsion Lab

**Teaching scheme** **Credits:** 2

3 hours practical per week

**Objectives**

*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.

| Sl.No | Equipments | Qty | Expt. No |
|---|---|---|---|
| 1 | Piston engines | 2 | 1 |
| 2 | Jet engine model | 1 | 2 |
| 3 | Forced convection apparatus | 1 | 3 |
| 4 | Free convection apparatus | 1 | 4 |
| 5 | Axial compressor blade row model with pressure tapping | 1 | 5 |
| 6 | Water tube manometers (20 tubes) | 2 | 5,8,9 |
| 7 | Subsonic wind tunnel | 1 | 4 |
| 8 | Propeller model static and total pressure probes | 4 | 8,9 |
| 9 | 2D travers in mechanism | 2 | 8 |
| 10 | Free jet set up | 1 | 9 |
| 11 | Aluminium plates with deflection mechanism | 1 | 10 |

**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

## EN010501A ENGINEERING MATHEMATICS IV
## (Common to all branches except CS & IT)

**Teaching scheme** **Credits: 4**

2 hours lecture and 2 hour tutorial per week

**Objectives:** *Use basic numerical techniques to solve problems and provide scientific techniques to decision making problems.*

**MODULE 1** Function of Complex variable (12 hours)

Analytic functions – Derivation of C.R. equations in cartision co-ordinates – harmonic and orthogonal properties – construction of analytic function given real or imaginary parts – complex potential – conformal mapping of $z^2$ , $\frac{1}{z}$ - Bilinear transformation – cross ratio – invariant property (no proof) – simple problems

**MODULE 2** Complex integration (12 hours)

Line integral – Cauchy's integral theorem – Cauchy's integral formula – Taylor's series- Laurent's series – Zeros and singularities – types of singularities – Residues – Residue theorem – evaluation of real integrals in unit circle – contour integral in semi circle when poles lie on imaginary axis.

**MODULE 3** Numerical solution of algebraic and transcendental equations (10 hours)

Successive bisection method – Regula –falsi method – Newton –Raphson method - Secant method – solution of system of linear equation by Gauss – Seidel method

**MODULE 4** Numerical solution of Ordinary differential equations ( 10 hours)

Taylor's series method – Euler's method – modified Euler's method – Runge – Kutta method (IV order) - Milnes predictor – corrector method

**MODULE 5** Linear programming problem (16 hours)

Definition of L.P.P., solution, optimal solution, degenerate solution – graphical solution –solution using simplex method (non degenerate case only) Big -M method – Duality in L.P.P. – Transportation problem –Balanced T.P. – initial solution using Vogel's approximation method - modi method (non degenerate case only)



**References**


1. B.V. Ramana – Higher Engg. Mathematics – Mc Graw Hill
2. M.R.Spicgel , S.Lipschutz , John J. Schiller, D.Spellman – Complex variables, schanm's outline series - Mc Graw Hill
3. S.Bathul – text book of Engg.Mathematics – Special functions and complex variables –PHI
4. B.S. Grewal – Numerical methods in Engg. and science - Khanna Publishers
5. Dr.M.K Venkataraman- Numerical methods in science and Engg -National publishing co
6. S.S Sastry - Introductory methods of Numerical Analysis -PHI
7. P.K.Gupta and D.S. Hira – Operations Research – S.Chand
8. Panneer Selvam– Operations Research – PHI
9. H.C.Taneja – Advanced Engg. Mathematics Vol II – I.K.International

## EN010 502(ME): Principles of Management

(Common with EN010 402(ME))

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To develop an understanding of different functional areas of management.*
- *To understand the functions and duties an individual should perform in an organisation.*

**Module I (12 hours)**

*Management Concepts*: Vision, Mission, Goals and Objectives of management-MBO-Scientific management- Functions of management- Planning- Organizing- Staffing-Directing- Motivating- Communicating- Coordinating- Controlling- Authority and Responsibility- Delegation- Span of control- Organizational structure- Line, Line and staff and Functional relationship.

**Module II (12 hours)**

*Personnel Management*: Definition and concept- Objectives of personnel management-Manpower planning- Recruitment and Selection of manpower- Training and development of manpower- Labour welfare- Labour turnover- Quality circle- Industrial fatigue- Industrial disputes-Method of settling disputes- Trade unions.

**Module III (12 hours)**

*Production management:* Objectives and scope of production management- Functions of production department- production management frame work- product life cycle-Types of production- Production procedure- Project planning with CPM and PERT- Basic concepts in network.

**Module IV (12 hours)**

*Financial Management*: Objectives and Functions of Financial Management- Types of Capital- Factors affecting working capital- Methods of financing.

*Cost Management*: Elements of cost- Components of cost- Selling Price of a product.

**Module V (12 hours)**

*Sales and Marketing Management*: Sales management- Concept- Functions of sales department- Duties of sales engineer- Selling concept and Marketing concept- Marketing-Definition and principles of marketing- Marketing management and its functions- Sales forecasting- Pricing- Advertising- Sales promotion- Channels of distribution- Market research.

**Text Books**

1. Koontz and Weihrich, *Essentials of Management*, Tata McGraw Hill.
2. Mahajan M., *Industrial Engineering and Production Management*, Dhanpat Rai and Co.
3. Kemthose and Deepak, *Industrial Engineering an Management,* Prentice Hall of India.

**Reference Books**

1. Martand Telsang, *Industrial Engineering and Production Management.*
2. Khanna O.P., *Industrial Engineering and Management*, Dhanpat Rai and Co.
3. Philip Kotler, *Marketing Management*, Prentice Hall of India.
4. Sharma S. C. & Banga T. R., *Industrial Organisation and Engineering Economics,* Khanna Publishers.
5. Prasanna Chandra, *Financial Management,* Tata McGraw Hill.

# AN010 503: Computer Programming

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Module I (15 hours)**

Introduction to computer programming; Various I/O functions; Data types; Constants and Variables; Escape Sequences; Type Casting; Preprocessor Directive; Storage Classes; Scope of Variables; Mathematical Operators; Relational Operators; Branching Instructions; Logical Operators; Conditional Operator; Precedence of Operators; Loops – for, while and do-while, break and continue instructions, Nested Loops; Switch statement; Evaluation of $e^x$, sin(x), cos(x) Numerical Integration using Trapezoidal and Simpson's rules.

**Module II (10 hours)**

Arrays; One Dimensional Arrays; Selection Sorting; Binary Searching; Various String Handling Functions; Multidimensional Arrays; Matrix Operations (Addition, Transpose and Multiplication); Sorting of Strings; Structure and Union; Array of Structures;

**Module III (10 hours)**

Functions; Call by Value Method; Stack; Passing One Dimensional and Multidimensional Arrays to a Function; Recursion; Writing Different String Handling Functions Using Simple Functions and Functions with Recursive Calls; Quick Sorting; Macros; Writing Macros for Simple Operations;

**Module IV (15 hours)**

Declaration of Pointers; Call by Reference Method; Pointer to a Structure; Pointer to an Array; Array of Pointers; Pointer to a Pointer; Self Referential Structure; Dynamic Memory Allocation; Reallocation of Memory; Linear Linked List; Circular Linked List; Double Linked List; Addition, Insertion and Deletion of Nodes from a Linked List; Command Line Arguments

**Module V (10 hours)**

Different types of Files; Reading, Writing, Appending and Rewriting of Text and Binary Files; Transfer of Data in Blocks; Moving of File Pointer in a File; Usage of bitwise AND, OR, NOT, XOR, Shift Left and Shift Right Operations



**Text Books**

1. Bryon S.Gottfried, *Programming with C Language.*

**Reference Books**

1. Balaguruswamy, *Programming in ANSI C.*
2. Deitel, *How to Program C*
3. Kamthane, *Programming with ANSI and Turbo C*

# AN010 504: Flight Dynamics I

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**
To study the performance of airplanes under various operating conditions

**Module I (10 hours)**
Drag on airplane
Forces and moments acting on a vehicle in flight - Equation of motion of rigid flight vehicles - Various types of drags - Drag polar of vehicles from low speeds to hypersonic speeds.

**Module II (10 hours)**
Variation of thrust / pressure with velocity and latitude.
Review of variation of thrust / power and S F C with altitude and velocity for various au breathing engine and rockets.

**Module III (12 hours)**
Air plane in level flight.
Performance of air plane in level flight - glide - climb - accelerated flight turn maneuvers take off and landing flight limitations.

**Module IV (12 hours)**
Flight testing.
Altitude definitions - Speed definitions - Air speed - Altitude and temperature measurements - Errors and calibration measurement of engine power. Charts and corrections - Flight determination of drag polar.

**Module V (16 hours)**
Static longitudinal stability.
Degree of freedom of rigid bodies in space - Static and dynamic stability - Purpose of controls in airplanes Static longitudinal stability - Basic equilibrium equation stability criterion - Effect of fuselages and nacelle, Influence of C G location - Power effects - stick fixed neutral points - Stick free stability - Hinge moment coefficient - Stick free neutral points - Symmetric maneuvers - Stick force gradients - Stick force per g.- Aerodynamic balancing - Determination of neutral points and maneuver points from flight test.



**Reference Books**

1. Lancaster, Jet propulsion engines, Princeston University press 1959
2. A.G. Kermode, Mechanics of Flight, Sir Issac Pitman 1962
3. A.G. Sutton, Science of flight, Penguin Books
4. E. I Houghton and A E Brock, Aerodynamics for engineers.

# AN010 505: Aerodynamics II

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

*To understand the behavior of airflow both internal and external in compressible flow regime with particular emphasis on supersonic flows.*

**Module I (8 hours)**

One dimensional compressible flow

Energy - Momentum - continuity and state equations - velocity of sound - adiabatic steady state flow equations - Flow through converging - diverging passages - Performance under various back pressures.

**Module II (12 hours)**

Normal, oblique shocks expansion waves

Prandtl equation and Rankine -Hugonoit relation - Normal shock equations - Pitot static tube - corrections for subsonic and supersonic flows - Oblique shocks and corresponding equations - Hodograph and pressure turning angle - shock polars - flow past wedges and concave corners – strong - weak and detached shocks.

**Module III (12hours)**

Expansion waves, Rayleigh and Fanno Flow

Flow past convex corners - Expansion hodograph - Reflection and interaction of shocks and expansion – waves - Families of shocks - Methods of Characteristics - Two dimensional supersonic nozzle contours- Rayleigh and Fanno Flow.

**Module IV (14 hours)**

Differential equations of motion for steady compressible flows

Small perturbation potential theory - solutions for supersonic flows - Mach waves and Mach angles - Prandtl Glauert affine transformation relations for subsonic flows - Linearised two dimensional supersonic flow theory – Lift - drag pitching moment and center of pressure of supersonic profiles.

**Module V (14 hours)**

Airfoil in high speed flows

Lower and upper critical Mach numbers - Lift and drag divergence - shock induced separation - Characteristics of swept wings - Effects of thickness - camber and aspect ratio of wings - Transonic area rule - Tip effects.

High speed wind tunnels

Blow down - indraft and induction tunnel layouts and their design features – Transonic, supersonic and hypersonic tunnels and their peculiarities - Helium and gas tunnels - Shock tubes - Optical methods of flow visualization.

**Text Books**

1. Rathakrishnan, E., "Gas Dynamics", Prentice Hall of India, 2003.

**Reference**

1. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronold Press, 1982.
2. Zucrow, M.J. and Anderson, J.D., "Elements of gas dynamics", McGraw-Hill Book Co., New York, 1989. ..
3. Mc Cornick. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, New York, 1979.
4. Anderson Jr., D., -"Modern compressible flows", McGraw-Hill Book Co., New York 1999

# AN010 506: Propulsion II

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

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

**Module I (12 hours)**
Aircraft and gas turbines
Impulse and reaction blading of gas turbines – Velocity triangles and power output – Elementary theory – Vortex theory – Choice of blade profile, pitch and chord – Estimation of stage performance – Limiting factors in gas turbine design- Overall turbine performance – Methods of blade cooling – Matching of turbine and compressor

**Module II (12 hours)**
Ramjet propulsion
Operating principle – Sub critical, critical and supercritical operation – Combustion in ramjet engine – Ramjet performance – Simple ramjet design calculations – Introduction to scramjet.

**Module III (12 hours)**
Fundamentals of rocket propulsion
Operating principle – Specific impulse of a rocket – internal ballistics- Rocket nozzle classification – Rocket performance considerations.

**Module IV (12 hours)**
Chemical rockets
Solid propellant rockets – Selection criteria of solid propellants – Important hardware components of solid rockets – Propellant grain design considerations – Liquid propellant rockets – Selection of liquid propellants. Cooling in liquid rockets – Hybrid rockets. Limitations of hybrid rockets Relative advantages of liquid rockets over solid rockets - Numerical Problems.

**Module V (12 hours)**
Advanced propulsion techniques
Electric rocket propulsion – Ion propulsion techniques – Nuclear rocket – Types – Solar sail- Preliminary Concepts in nozzle less propulsion.

**Text Books**

1.Sutton, G.P., "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 5th Edn. 1993.
2.Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison -Wesley Longman INC, 1999.

**Reference Books**

I. Cohen, H., Rogers, G.F.C. and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman Co., ELBS Ed., 1989.
1.Gorden, C Y., "Aero thermodynamics of Gas Turbine and Rocket Propulsion", AIAA Education Series, New York, 1989.
2.Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", Standard Publishers, New Delhi, 1988.

## AN010 507: Wind tunnel Lab

**Teaching scheme**
3 hours practical per week

**Credits:** 2

List of experiments

1. Calibration of subsonic tunnels.
2. Calibration of supersonic tunnels.
3. Determination of Mach number of subsonic and supersonic waves using wind tunnel.
4. Measurement of pressure, velocity and force by three component balances.
5. Measurement of pressure, velocity and force by six component balance method.
6. To measure angular distribution of velocities in subsonic wave.
7. To measurement angular distribution of velocities in supersonic wave.
8. Effect of shock wave.
9. Turbulence measurements.
10. Study of flow visualization by optical method



**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

# AN010 508: Propulsion Lab II

**Teaching scheme** **Credits:** 2
3 hours practical per week

**Objectives**

*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 magneto and ignition system.
3. Study of an aircraft jet engine compressor.
4. Study of jet engine combustion chamber.
5. Study of jet engine turbine.
6. Study of forced convective heat transfer over a flat plate.
7. Study of free convective heat transfer over a flat plate
8. Study of free jet.
9. Study of wall jet.
10. Study of ram jet.



**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

# AN010 601: Avionics

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

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

**Module I (12 hours)**
Introduction to avionics
Need for Avionics in civil and military aircraft and space systems -Integrated Avionics and Weapon system -Typical avionics sub systems -Design and Technologies.

**Module II (12 hours)**
Principles of digital systems
Digital Computers – Digital number system - number systems and codes-Fundamentals of logic and combinational logic circuits –Digital arithmetic – interfacing with analogue systems - Microprocessors – Memories.

**Module III (12 hours)**
Digital avionics architecture
Avionics system architecture– salient features and applications of Data buses MIL – STD 1553 B – ARINC 429 – ARINC 629.

**Module IV (12 hours)**
Flight deck and cockpits
Control and display technologies CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) - Civil cockpit and military cockpit : MFDS, HUD, MFK, HOTAS

**Module V (12 hours)**
Avionics systems
Communication Systems - Navigation systems - Flight control systems - Radar electronic warfare - Utility systems Reliability and maintainability - Certification.



**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.

**Reference Books**

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989.
2. Spitzer, C.R., "Digital Avionic Systems", Prentice Hall, Englewood Cliffs, N.J., USA., 1987.
3. Brain Kendal, "Manual of Avionics", The English Book House, 3rd Edition, New Delhi, 1993.

# AN010 602: Experimental Aerodynamics

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

*To present the measurement techniques involved in aerodynamic testing.*

**Module I (12 hours)**

Wind tunnel testing

Low speed wind tunnels-estimation of energy ratio and power required supersonic win tunnels - calculation of running time and storage tank requirements.

**Module II (12 hours)**

Experiments in subsonic wind tunnels

Estimation of flow angularity and turbulence factor-calculation of CL and CD on aero foils from pressure distribution- CD from wake survey-Test section average velocity using traversing rakes-span wise load distribution for different taper ratios of wing

**Module III (12 hours)**

Experiments in high speed tunnels

Mach number estimation in test section by pressure measurement and using a wedge – preliminary estimates of blowing and running pressures, nozzle area ratios, mass flow for a given test section size and Mach number-starting problem and starting loads.

**Module IV (12 hours)**

Measurement techniques

Hot wire anemometer and laser Doppler anemometer for turbulence and velocity measurements-Use of thermocouples and pyrometers for measurement of static and total temperatures-Use of pressure transducers, Rotameters and ultrasonic flow meters.

**Module V (12 hours)**

Special problems

Pitot-static tube correction for subsonic and supersonic Mach numbers-boundary layer velocity profile on a flat plate by momentum-integral method -Calculation of CD from wall shear stress-Heating requirements in hypersonic wind tunnels-Re-entry problems.



**Reference Books**

1. Rae W.H and Pope. A "Low speed wind tunnel testing" John Wiley Publication, 1984
2. Pope. A and Goin. L "High speed wind tunnel testing" John Wiley, 1985
3. Rathakrishnan. E "Instrumentation, Measurement and Experiments in Fluids", CRC Press, London, 2007

# AN010 603: Aircraft Structures II

**Teaching scheme** **Credits:** 4

3 hours lecture and 1 hour tutorial per week

**Objectives**

*To study the behaviour of various aircraft structural components under different loading conditions*

**Module I (12 hours)**

Unsymmetrical bending

General, Principal axis and neutral axis methods- bending stresses in beams of symmetric sections with skew loads- bending stresses in beams of unsymmetrical sections.

**Module II (12 hours)**

Shear flow in open sections

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

**Module III (12 hours)**

Shear flow in closed sections

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

**Module IV (12 hours)**

Buckling of plates

Rectangular sheets under compression, local buckling stress of thin walled section-Crippling stresses by Needham's and Gerard's methods, Thin walled column strength-sheet stiffener panels-Effective width.

**Module V (12 hours)**

Stress analysis in wing and fuselage

Shear resistant web beams-Tension field web beams(Wagner's) – Shear and bending moment distribution for cantilever and semi-cantilever types of beams-loads on aircraft – lift distribution-V-n diagram-Gust loads



**Text Books**

1. Peery, D. J., and Azar, J. J., "Aircraft Structures", 2nd edition, McGraw–Hill, N.Y., 2007.
2. Megson, T.M.G., "Aircraft Structures for Engineering Students", Edward Arnold, 2007.

**Reference Books**

1. Bruhn. E. H. "Analysis and Design of Flight vehicles Structures", Tri – state off set company, USA, 1985.
2. Rivello, R. M., "Theory and Analysis of Flight Structures", McGraw-Hill, 1993.

# AN010 604: Heat Transfer

**Teaching scheme** **Credits: 4**
3 hours lecture and 1 hour tutorial per week

**Objectives**

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

**Module I (12 hours)**
Heat conduction
Basic Modes of Heat Transfer - One dimensional steady state heat conduction- Composite Medium Critical thickness - Effect of variation of thermal Conductivity - Extended Surfaces - Unsteady state. Heat Conduction: Lumped System Analysis - Heat Transfer in Semi infinite and infinite solids - Use of Transient - Temperature charts -Application of numerical techniques.

**Module II ( 12 hours)**
Convective heat transfer
Introduction - Free convection in atmosphere free convection on a vertical flat plate - Empirical relation in free convection - Forced convection - Laminar and turbulent convective heat transfer analysis in flows between parallel plates, over a flat plate and in a circular pipe. Empirical relations, application of numerical techniques in problem solving.

**Module III (12 hours)**
Radiative heat transfer
Introduction to Physical mechanism - Radiation properties - Radiation shape factors -Heat exchange between non - black bodies - Radiation shields.

**Module IV (12 hours)**
Heat exchangers
Classification - Temperature Distribution - Overall heat transfer coefficient - Heat Exchange Analysis LMTD Method and E-NTU Method.

**Module V (12 hours)**
Heat transfer problems
Heat transfer problems in aerospace engineering High-Speed flow Heat Transfer, Heat Transfer problems in gas turbine combustion chambers - Rocket thrust chambers - Aerodynamic heating - Ablative heat transfer.

**Text Books**

1. J. Yunus A. Cengel., "Heat Transfer -A practical approach", Second Edition, Tata McGraw-Hill, 2002.
2. Incropera. F.P .and Dewitt.D.P. "Introduction to Heat Transfer", John Wiley and Sons -2002.

**Reference Books**

1.Lienhard, J.H., "A Heat Transfer Text Book", Prentice Hall Jnc. 1981.
2.Holman, J.P. "Heat Transfer", McGraw-Hill Book Co., Inc., New York, 6th Edn. 1991.
3.Sachdeva S C, "Fundamentals of Engineering Heat & Mass Transfer", Wiley Eastern Ltd., New Delhi, 1981.
4.Mathur M. and Sharma, R.P. "Gas Turbine and Jet and Rocket Propulsion", Standard Publishers, New Delhi 1988.

# AN010 605: Theory of Vibration

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To understand the basic concepts and issues related to vibration*

**Module I (12 hours)**
Fundamentals of vibration
Introduction, Definitions, Vector method of representing harmonic motions, Additions of two Simple Harmonic Motions of the same Frequency, Beats Phenomenon.
Undamped free vibrations of single degree of freedom
Introduction, Derivation of differential equation, Solution of differential equation, Torsional Vibrations, equivalent stiffness of Spring Combinations, Energy Method.

**Module II (12 hours)**
Damped free vibrations of single degree of freedom system
Introduction, Different types of Damping, Free Vibrations with viscous damping, Logarithmic decrement, Viscous dampers, Dry Friction or Coulomb damping, Solid or Structural damping.
**Module III (12 hours)**

Forced vibrations with constant harmonic excitation
Introduction, Forced Vibrations with constant harmonic excitation, Forced Vibrations due to excitation of the Support, Energy dissipated by damping, Forced vibrations with Coulomb damping, Forced vibrations with Structural damping, Determination of Equivalent viscous damping from frequency-response curve, Vibration isolation and transmissibility, Vibration measuring instruments, Critical speed of shafts
**Module IV (12 hours)**

Two degree of freedom systems
Introduction, Principal modes of Vibration, Other cases of simple two degrees of freedom systems, Combined rectilinear and angular modes, Systems with damping, Undamped forced vibrations with Harmonic excitation, Vibration absorbers, Vibration Isolation Natural frequencies and mode shapes (eigenvalues and eigenvectors), orthogonal properties of normal modes, Introduction to Model analysis,

**Module V (12 hours)**
Continuous systems – vibrating strings - axial vibration of rod – transverse vibration of beams – torsional vibration of shafts.

**Text Books**

1. Leonard Meirovitch, "Fundamentals of Vibrations", International Edition, McGraw-Hill, 2001.
2. Singiresu S Rao, "Mechanical Vibrations", Fourth Edition, Pearson.
3. V. P. Singh, "Mechanical Vibrations", Dhanpat Rai & sons
4. William T Thomson, "Theory of Vibration with applications", Prentice Hall, 1993.

# AN010 606L01: Composite Structures

**Teaching scheme** **Credits: 4**
3 hours lecture and 1 hour tutorial per week

**Objectives**

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

**Module I (12hours)**
Stress strain relation
Introduction- Advantages and application of composite materials - reinforcements and matrices – polymer matrix composite - metal matrix composite - ceramic matrix composite - Generalised Hooke's Law – Elastic constants for anisotropic, orthotropic and isotropic materials.

**Module II (12hours)**
Micro mechanics – Mechanics of materials approach, elasticity approach to determine material properties – Macro Mechanics – Stress-strain relations with respect to natural axis, arbitrary axis – Determination of material properties. Experimental characterization of lamina.

**Module III (14hours)**
Classical and improved theories of laminated structures. A, B, D matrices
Deformation due to extension/shear and bending/torsion- – angle ply and cross ply laminates- Special cases of laminate stiffness

**Module IV (12 hours)**
Sandwich constructions-Basic design concepts of sandwich construction -Materials used for sandwich construction
Concepts of failure of laminates-Tensile failure of fiber composites Compressive failure of fiber composites Effect of multiaxial stresses (failure criteria by Tsai-Wu, Tsai-Hill, etc.)

**Module V (10hours)**
Laminated plates- Governing differential equation for a general laminate
Laminated composite beams –Governing differential equation for orthotropic symmetric laminate-application of boundary conditions



**Text Books**

1. Calcote, L R. "The Analysis of laminated Composite Structures", Von – Noastrand Reinhold Company, New York 1998.
2. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1998, II edition.

**Reference Books**

1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
2. Lubin, G., "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1989.

# AN010 606L02: Fatigue and Fracture

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To study the concepts of estimation of the endurance and failure mechanism of components*

**Module I (12 hours)**
Fatigue of structures
S.N. curves -Endurance limits -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.

**Module II (12 hours)**
Statistical aspects of fatigue behaviour
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.

**Module III (12 hours)**
Physical aspects of fatigue and fracture
Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces - Strength and stress analysis of cracked bodies - Potential energy and surface energy - Griffith's theory - Irwin - Orwin extension of Griffith's theory to ductile materials - Effect of thickness on fracture toughness - stress intensity factors for typical geometries.

**Module IV (12 hours)**
Fatigue design and testing
Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.

**Module V (12 hours)**
Fundamentals of failure analysis
Common causes of failure. Principles of failure analysis. Fracture mechanics approach to failure problems. Techniques of failure analysis. Service failure mechanisms - ductile and brittle fracture, fatigue fracture, wear failures, fretting failures, environment induced failures, high temp. failure. Faulty heat treatment and design failures, processing failures (forging, casting, machining etc.)

**Text Books**

1. Prasanth Kumar – "Elements of fracture mechanics" – Wheeter publication, 1999.
2. Barrois W, Ripely, E.L., "Fatigue of aircraft structure", Pe/gamon press. Oxford, 1983.

**Reference Books**

1. Sin, C.G., "Mechanics of fracture" Vol. I, Sijthoff and w Noordhoff International Publishing Co., Netherlands, 1989.
2. Knott, J.F., "Fundamentals of Fracture Mechanics", Buterworth & Co., Ltd., London, 1983
3. Subra suresh, "Fatigue of materials" , II edition, 1998.
4. T. L. Anderson, "Fracture mechanics: Fundamentals and applications", III edition, 2004.

# AN010 606L03: Finite Element Analysis

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To learn the mathematical background of finite element analysis*
- *To solve structural mechanics problems using finite element approach*

**Module I (12 hours)**
Introductory Concepts: Introduction to FEM. Brief History. General FEM procedure. Applications of FEM in various fields. Advantages and disadvantages of FEM.
Differential Equations in different fields : Types of Differential Equations. Primary and Secondary Variables and types of Boundary Conditions.
Approximate solution of differential equations-- Weightaed residual techniques, collocation, Least squares and Galerkin methods.

**Module II (12 hours)**
FEM Procedure : Definitions of various terms used in FEM likeelement, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, essential boundary conditions, natural boundary conditions, homogeneous and nonhomogeneous boundary conditions.
Minimization of a functional. Principle of minimum total potential. Piecewise Rayleigh-Ritz method. Comparison with weighted residual method.

**Module III (12 hours)**
Piecewise approximations. Basis of Finite Element Methods. Formulation of matrix method--.stiffness matrix.; transformation and assembly concepts.
Example problems in one dimensional structural analysis (Plane Trusses, Bar and Beam) and heat transfer.

**Module IV (12 hours)**
Two dimensional finite element formulations. Three nodded triangular element, four nodded rectangular element, compatibility, four nodded quadrilateral element, eight nodded quadrilateral element.
Various types of 2-D-elements Application to plane stress, plane strain and axisymmetric problems.

**Module V (12 hours)**
Natural coordinates and coordinate transformations. Isoperimetric elements. Applications to two and three-dimensional problems
Convergence criterion, patch test and errors in finite element analysis. Method of Elimination.

**Text Books**

1. Robert D.Cook, "Concepts and applications of Finite Element Analysis", Wiley India, Fourth Edition, 2003.
2. Daryl L.Logan, "A first course in the Finite Element Method", Cengage Learning, Fourth Edition, 2007.

**Reference Books**

1. Reddy J.N. "An Introduction to Finite Element Method", McGraw-Hill, 2000.
2. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw-Hill, 2000.
3. Bathe, K.J. and Wilson, E.L., "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.

# AN010 606L04: Operation Research

**Teaching scheme** **Credits: 4**
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To understand the basic concepts of operation research*

**Module I (12hours)**
Development – Definition– Characteristics and Phases – Types of models – operation Research models–applications. Allocation: Linear Programming Problem Formulation – Graphical solution– Simplex method– Artificial variables techniques -Two–phase method, Big-M method – Duality Principle.

**Module II (12hours)**
Transportation problem– Formulation – Optimal solution, unbalanced transportation problem–Degeneracy. Assignment problem – Formulation – Optimal solution – Variants of Assignment Problem-Travelling Salesman problem. Sequencing – Introduction – Flow –Shop sequencing–n jobs through two machines–n jobs through three machines – Job shop sequencing – two jobs through 'm' machines.

**Module III (10hours)**
Replacement: Introduction – Replacement of items that deteriorate with time – when money value is not counted and counted – Replacement of items that fail completely, group replacement.

**Module IV (12 hours)**
Theory of games: Introduction – Minimax (maximin) – Criterion and optimal strategy – Solution of games with saddle points – Rectangular games without saddle points – 2 X 2 games–dominance principle– m X 2 & 2 X n games -graphical method

**Module V (14 hours)**
Inventory: Introduction – Single item – Deterministic models – Purchase inventory models with one price break and multiple price breaks – shortages are not allowed – Stochastic models–demand may be discrete variable or continuous variable – Instantaneous production. Instantaneous demand and continuous demand and no set up cost.
Waiting lines: Introduction – Single Channel – Poisson arrivals – exponential service times – with infinite population and finite population models– Multichannel

**Text Books**

1. S.D.Sharma, "Operations Research", eleventh edition, Kedar Nath and Ram Nath & Co., 1997

**Reference Books**

1. Wagner, "Operations Research", PHI Publications.
2. A. M. Natarajan, P. Balasubramani and A. Tamilarasi, "Operations Research", Pearson Education.
3. J.K.Sharma, "Operations Research", MacMilan.
4. R.Pannerselvam, "Operations Research", PHI Publications.

# AN010 606L05: Ecology and Environment

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To impart the basic knowledge of surroundings and latest environmental issues.*

**Module I (12hours)**
Definition, Scope & Importance, Need For Public Awareness- Environment definition, Eco system – Balanced ecosystem, Human activities – Food, Shelter, Economic and social Security.Effects of human activities on environment-Agriculture, Housing, Industry, Mining and Transportation activities, Basics of Environmental Impact Assessment. Sustainable Development.

**Module II (12hours)**
Natural Resources- Water Resources- Availability and Quality aspects. Water borne diseases, Water induced diseases, Fluoride problem in drinking water. Mineral Resources, Forest Wealth, Material cycles- Carbon,Nitrogen and Sulphur Cycles.Energy – Different types of energy, Electro-magnetic radiation. Conventional and Non-Conventional sources – Hydro Electric, Fossil Fuel based Nuclear, Solar, Biomass and Bio-gas. Hydrogen as an alternative future source of Energy

**Module III (12hours)**
Environmental Pollution and their effects. Water pollution, Land pollution. Public Health aspects, Solid waste management. Current Environmental Issues of Importance: Population Growth, Climate Change and Global warming-Effects, Urbanization-Automobile pollution.- Acid Rain, Ozone Layer depletion, Animal Husbandry

**Module IV (`12 hours)**
Air Quality Sources and effects of air pollution, major air pollutants, air quality control, treatment of emissions, dispersion of air pollutants. Noise Pollution Effect of noise on human health and its control

**Module V (12 hours)**
Environmental Protection- Role of Government, Legal aspects, Initiatives by Non-governmental Organizations (NGO), Environmental Education, Women Education.



**Text Books**

1. Benny Joseph, "Environmental studies", Tata McgrawHill, 2005.
2. Dr. D. L. Manjunath, "Environmental studies", Pearson Education, 2006.
3. M. Anji Reddy, "Text book of Environmental science and Technology", B. S. Publication.
4. R. Rajagopalan, "Environmental studies", Oxford Publication, 2005.

## AN010 606L06: Non Destructive Testing

**Teaching scheme** **Credits:** 4
3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To understand the various non destructive testing techniques*

**Module I (12 hours)**
Introduction- Visual methods: Optical aids, In-situ metallography, Optical holographic methods, Dynamic inspection.

**Module II (12 hours)**
Penetrant flaw detection – Principles – Process - Penetrant systems - Liquidpenetrant materials – Emulsifiers - cleaners developers – sensitivity – Advantages – Limitations - Applications.

**Module III (12 hours)**
Radiographic methods - Limitations - Principles of radiography - sources of radiation, Ionising radiation - X-rays sources, gama-rays sources Recording of radiation - Radiographic sensitivity - Fluoroscopic methods.
Ultrasonic testing of materiald: Advantages, disadvantages, Applications, Generation of. Ultrasonic waves, general characteristics of ultrasonic waves - methods and instruments for ultrasonic materials testing.

**Module IV (12 hours)**
Magnetic methods: Advantages, Limitations, Methods of generating fields: magnetic particles and suspending liquids Magnetography, field sensitive probes: applications.
Electrical methods: Eddy current methods: potential-drop methods, applications.

**Module V (12 hours)**
Electromagnetic testing: Magnetism: Magnetic domains: Magnetization curves: Magnetic Hysteresis: Hysteresis-loop tests: comparator - bridge tests Absolute single-coil system: applications.
Other methods: Acoustic Emission methods, Acoustic methods: Leak detection: Thermal inspection.



**Text Books**
1. R. Halmshaw, "Non-Destructive Testing".

**Reference**
1. Metals Handbook Vol.II, Nondestructive inspection and quality control

# AN010 607: Heat Engines Laboratory

(Common with ME010 607 and AU010 607)

**Teaching scheme** **Credits:** 2

3 hours practical per week

**Objectives**

- *To provide experience on testing of IC engines performance.*

Study of systems and components of IC Engines and automobiles - study of dynamometers used in engine testing - study of IC Engine repairs and maintenance.

Study of boilers, boiler mountings and accessories - study of steam engine parts and systems.

Testing of IC engines • Performance analysis of IC engine using computerized test rig- Load test on petrol and diesel engines- determination of indicated and brake thermal efficiencies - mechanical efficiency - relative efficiency - volumetric efficiency - air-fuel ratio and compression ratio - valve timing diagram - retardation test - Morse test - heat balance - effect of varying the rate of cooling water and varying the speed on the performance characteristics of engines.

Testing of steam boiler - boiler trial - steam calorimeters and steam nozzles - performance test on steam engines - performance test on steam turbines.

Testing of fuels and lubricants - determination of flash and fire points of petroleum products - determination of kinematics and absolute viscosity of lubricating oils - determination of calorific values



**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

# AN010 608: Aero Engines Lab

**Teaching scheme** **Credits:** 2
3 hours practical per week

**Objectives**

- *To introduce the knowledge of the maintenance and repair of both piston and jet aero engines and the procedures followed for overhaul of aero engines.*

List of Experiments

1. Dismantling of a piston engine
2. Engine (Piston Engine) - cleaning, visual inspection, NDT checks.
3. Piston Engine Components - dimensional checks.
4. Study of carburetor.
5. Piston – Engine reassembly.
6. Dismantling of a jet engine
7. Jet Engine – identification of components & defects.
8. Jet Engine – NDT checks and dimensional checks
9. Jet Engine – reassembly.
10. Engine starting procedures.

**Internal Continuous Assessment** *(Maximum Marks-50)*

50%-Laboratory practical and record
30%- Test/s
20%- Regularity in the class

**End Semester Examination** *(Maximum Marks-100)*

70% - Procedure, conducting experiment, results, tabulation, and inference
30% - Viva voce

## AN010 701 Computational Fluid Dynamics

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To develop and understand the major approaches and methodologies used in CFD.*
- *To increase skills in a) implementing and using basic CFD methods b) computer use and programming.*

**Module I – Fundamental concepts**

Introduction, Basic equation of fluid dynamics, incompressible inviscid flows, Mathematical properties of fluid dynamics equation, elliptical, parabolic and hyperbolic equation – discretisation of partial differential equation, Transformations and grids, explicit infinitesimal difference methods of subsonic , supersonic and viscous flows

**Module II – Panel Methods**

Introduction, Numerical source panel methods, non lifting flows over arbitrary bodies, vortex panel method, lifting flows over arbitrary bodies, modern low speed aerofoils,- other applications, source and vortex panel methods

**Module III – Discretisation**

Boundary layer equation and methods of solutions , Implicit time dependant methods for inviscid and viscous compressible flows , concepts of numerical dissipation, stability property of explicit and implicit method, conservative upwind discretisation for hyperbolic system, and further advantages of upwind differencing

**Module IV – Finite Element Techniques**

Finite element techniques in CFD, Introduction, Strong and weak formulations of boundary value problem. Strong formulation weighted residual formulation- galerkin formulation weak formulation- variational formulation, piecewise defined shape function, implementation of finite element method- solution procedure.

**Module V – Finite volume Techniques**

Cell- centred formulation, Lav- vendroff time stepping , Runge Kutta time stepping, multi stage time stepping, finite difference method like finite volume techniques, central and upwind type disretisation treatment of derivatives.

***References:***

*1. Fletchre C A, "Computational Techniques for fluid dynamics", Vol I and II, Springer*
*2. John F Wendt, "Computational fluid dynamics" - An Introduction, springer*
*3. J D Anderson, "computational fluid dynamics - Mc Graw Hill*

## AN 010 702 EXPERIMENTAL STRESS ANALYSIS

**Teaching scheme** **Credits**: 4
2 hours lecture and 2 hours tutorial per week

**Objectives:**

- *To make students aware of various measurement methods of finding the response of the structure to different types of load.*
- *To make students aware of experimental planning and procedures adopted in laboratory.*

### Module I - MEASUREMENTS

Principles of measurements, Accuracy, Sensitivity and range of measurements. Properties of Strain Gage Systems, Types of Strain Gages, Electrical Resistance strain gauges, semiconductor strain gauges, strain gauge circuits Grid- Method of Strain Analysis Transducer applications, Recording instruments for static and dynamic applications.

### Module II – EXTENSOMETERS

Mechanical, Optical Acoustical and Electrical extensometers and their uses, Advantages and disadvantages.

Coating Stresses, Failure Theories, Brittle Coating Crack Patterns, Resin and Ceramic Based Brittle Coating, Test Procedure, Analysis of Brittle Coating Data.

### Module III - ELECTRICAL RESISTANCE STRAIN GAUGES

Principle of operation and requirements, Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross sensitivity, Rosette analysis- Three Element Rectangular Rosette, Delta Rosette, Torque gauge, Stress Gage, Plane Shear Gage

Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators.

### Module IV – PHOTOELASTICITY

**Theory of Photoelasticity:** Introduction, Temporary Double Refraction, Stress Optic Law, Relative Retardation, Stressed Model in Plane Polariscope, Effect of Principal Directions, Effect of Principal Stress Difference, Stressed Model in Circular Polariscope, Light and Dark Field arrangements, Tardy Compensation, Fringe Sharpening and Multiplication by Partial Mirrors

Two dimensional photoelasticity, Concepts of light-photo-elastic effects, stress optic law, Interpretation of fringe pattern, Compensation and separation techniques, Photoelastic materials. Introduction to three dimensional photoelasticity.

**Module V - NON-DESTRUCTIVE TESTING**

Fundamentation of NDT, Radiography, ultrasonics, Magnetic particle inspection, Fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique, Fundamentals of brittle coating methods, Introdcution to Moire techniques, Holography, ultrasonic C-Scan, Thermography, Fibre-optic Sensors.

***Reference :***

*1. Dally, J.W., and Riley, W.F., " Experimental Stress Analysis ", McGraw Hill Inc., New York, 1978.*
*2. Hetyenyi, M., " Hand Book of Experimental Stress Analysis ", John Wiley and Sons Inc., New York, 1972.*
*3. Srinath, L.S., Raghava, M.R., Lingaiah, K.Gargesha, G.Pant B., and Ramachandra, K., " Experimental*
*Stress Analysis ", Tata*
*McGraw Hill, New Delhi, 1984.*
*4. Pollock A.A., " Acoustic Emission in Acoustics and Vibrations progress ", ed. by Stephens R.W.B.,*
*Chapman and Hall, 1983.*

# AN 010 703 AIRCRAFT DESIGN

**Teaching scheme** **Credits**: 4
2 hours lecture and 2 hour tutorial per week

Objective:

- To make students aware of the preliminary work that's involved in designing an aircraft.
- To make the students aware of the monitoring principles of each component of an aircraft.

MODULE -1

INTRODUCTION

Literature review-classification based on purpose and configuration, factors affecting configuration-comparative study of aircrafts-phases of airplane design-conceptual design-preliminary design-detail design-seven intellectual pivot points-requirements-weight of airplane-critical performance parameter-configuration layout-better weight estimate-performance analysis-constraint diagram

MODULE -2

WEIGHT ESTIMATION

Take off weight build up-empty weight estimation-fuel fraction estimation-mission profiles-mission segment weight fractions-SFC- L/D estimation-Take off weight calculation- actual weight estimation- approximate weight estimation- comparative study-Thrust to weight ratio

MODULE -3

AEROFOIL AND GEOMETRY SELECTION

Airfoil selection-airfoil geometry-airfoil lift and drag- Aerodynamic forces- aerodynamic coefficients- lift, drag- airfoil families- airfoil design-design lift coefficient-aerofoil thickness ratio-airfoil consideration-airfoil nomenclature-wing geometry-aspect ratio-taper ratio

Peculiarities in layout, Designing for manufacturability, Maintenance, Operational costs, Interactive design

MODULE -4

ENGINE SELECTION LANDING GEAR AND SUB SYSTEM SELECTION

Introduction- Jet engine thrust consideration-Turbojet installed thrust-comparitive performance study of different types of engines

Landing gear arrangements-tyre sizing-shock absorbers-castoring-wheel geometry-gear retraction geometry –seaplanes and sub systems

AREA CALCULATION , TAKE OFF AND LANDING DISTANCE CALCULATION

Wetted area- fuselage-undercarriage-wing tail-1/4 flap deflection-3/4 flap deflection-Performance analysis-power required-rate of climb-range-stalling speed-landing distance-take off distance. - Problems

MODULE -5
DESIGN OF MAJOR AIRPLANE COMPONENTS

*a)* Wing design:
Airworthiness requirements, V-n diagram, loads, Elements of wing design, Structural features.
*b)* Fuselage design: Loads on fuselage, Elements of fuselage design, Determination of tail surface areas, Structural features.
*c)* Landing gear design:
Loads or Landing gear, Preliminary landing gear design
*d)* Elements of computer Aided Design

***References:***

*1. Torenbeek,E., " Synthesis of Subsonic Airplane Design ", Delft University Press,U.K.1986*
*2. Kuechemann,D., " Aerodynamic Design of Aircraft ", Pergamon Press,1978*
*3. Raymer,D.P., " Aircraft Conceptual Design ", AIAA Series,1989.*
*4. Roskam, J., Aircraft Design, Published by the author as an 8 volume set, 1985-1990.*

## AN 010 704 Flight Dynamics II

**Teaching scheme** **Credits**: 4

2 hours lecture and 1 hour tutorial per week

**Objectives**

- *To familiarize students with dynamics of flight vehicles and*
- *The course introduces students to the performance, stability, and control of an airplane.*

**Module I – Airplane Performance: Accelerated flight**

Introduction , Level turn, the pull-up and pull-down maneuvers , limiting case for large load factor , the V-n diagram, energy concept, accelerated rate of climb, take off performance, landing performance.

**Module II - Airplane Performance: Steady flight**

Equation of motion of steady level flight, thrust requirements, fundamental parameters: thrust to weight ratio , wing loading , thrust available and the maximum velocity of the airplane, power required and power available, minimum velocity: stall and high lift devices, rate of climb , service and absolute ceilings , range and endurance .

**Module III – Lateral and directional stability**

Dihedral effect, lateral control, coupling between rolling and yawing moments, adverse yaw effects, aileron reversal, static directional stability, weather cocking effect, rudder requirements, One engine in operative condition, rudder lock.

**Module IV – Dynamic Longitudinal Stability**

Equations of motion, Stability derivatives, characteristic equation of stick fixed case, modes and stability criterion, effect of freeing, stick brief description of lateral and directional stability, spiral divergence, Dutch roll, auto rotation and spin.

**Module V – Dynamic Lateral Stability**

Lateral Stability equation of a disturbed aircraft, stability derivatives , characteristic equation for stick fixed case , effect of reeling , brief description of lateral and directional dynamic stability, spiral divergence, Dutch roll, automatic control, determination of neutral points,

***Reference:***


1. *John D Anderson, Jr , Performance and Design, Tata Mc Graw Hill , 1999*
2. *Perkins C D and Hage R E , Airplane performance stability and control, Wiley*
3. *Nelson R C, Flight stability and automatic control , Tata Mc Graw Hill*

**AN 010 705 Aircraft System And Instrumentation**

**Teaching scheme** **Credits**: 4

2 hours lecture and 1 hour tutorial per week

**Objectives**

- *To familiarize the student with various systems and instruments used in an aircraft.*

**Module I - Engine Systems**

*Fuel system for piston & Jet engines:-* Components and its functions, *Lubrication system for piston and Jet engines:-* Function's of lubrication system, *starting and ignition systems:-*Battery ignition, low tension and High tension ignition systems for piston engines

**Module II - Aircraft Systems**

*Hydraulic System:-* Basic hydraulic system with hand pump and power pump; study of typical workable system components, and its operation. *Pneumatic System:-* Working principle, different types, Typical Pneumatic Power System, Components of landing gear system, classification of shock absorbers, landing gear retraction systems ,Brake system: Independent Brake System, power brake control systems.

**Module III - Auxilary Systems**

Basic Air cycle system, vapour cycle system, Refrigeration cycle, Oxygen system & its types, De icing & anti icing systems, wind shield wiper system, Fire protection system

**Module IV- Airplane Control System**

Flight control systems,-cable, push-pull & torque tube system flight control system hardware, mechanical linkage & mechanisms, Hydraulic operated control systems, Digital fly by wire system, communication & Navigation system, basic radio principles & equipments, Radio Altimeter, ELT, VHF VOR, Instrument landing system, DME, ADF.

**Module V - Aircraft Instruments**

General, Aircraft Pressure guage, Pitot static system, Altimeters, Rate –of-limb indicators, Air speed indicator, mach indicator . Turn & Bank indicator, Angle of attack indicator. Tachometers Mechanical & Electrical, Gyroscopic instruments, Gyroscopic inertia & precession; Gyro-horizon indicator, Magnetic compass, Auto pilot system, principle of operation, components, Synchronoscope, Computer & recorders.

***References:***


*(a) General Hand books of Airframe and Power Plant Mechanics (AC65-15A , 9A)-The English Book Store New Delhi.*

*(b) Pallet EHJ "Aircraft Instruments & Principle", Pitman & Co.*

*(c) Aircraft Electrical Systems E.H.J. Pallet (IIIrd edition)*

## AN 010 706L01 Theory of Plates and Shells

**Teaching Scheme** **Credit:4**

2 hours lecture and 2hours tutorial per week.

**Objective** :

*To develop the skills for the analysis of advanced structures in civil engineering.*

**Module 1 ( 12 hrs)**

**Plates** – Introduction – Classification of plates – Thin plates and thick plates – Assumptions in the theory of thin plates – Differential equation for cylindrical bending of rectangular plates – Pure bending of plates – Slope and curvature of slightly bent plates – Relation between bending moment and curvature in pure bending.

**Module 2 (12 hrs)**

**Laterally loaded rectangular plates** – Small deflections of laterally loaded thin plates – Differential equation of plates – Derivation of fourth order differential equation – Boundary conditions – Simply supported, built- in and free edges.

**Module 3 ( 12 hrs)**

**Shells** – Structural behaviour of shells – Parts of a shell – Classification of shells – Translational, rotational and ruled surfaces – Gauss curvature – Synclastic and anticlastic surfaces – Hyperbolic paraboloid – Elliptic paraboloid – Conoid.

**Module 4 ( 12 hrs)**

**Classical theories of shells** – Thin shell and thick shell – Stress resultants – Membrane theory of cylindrical shells – Formulation of equilibrium equations – Bending theory of cylindrical shells – Equilibrium equations – Beam theory.

**Module 5 ( 12 hrs)**

**Circular cylindrical shells** – Equilibrium equations – Expression for strain – Deformation of circular cylindrical shell – Cylindrical shell with uniform internal pressure – Pressure vessels – Calculation of bending moment and stresses in pressure vessels – attenuation length of edge effects.

**References:**


1. S.P Timoshenko, S.W Krieger, *Theory of plates and shells*, Mc Graw Hill.
2. J Ramachandran, *Thin shell theory and problems*, Universities press.
3. Krishna Raju N., *Advanced Reinforced Concrete Design*, CBS Publishers and distributers, New Delhi.
4. G.S Ramaswamy, *Design and Construction of Concrete Shell Roofs*, Tata-McGraw Hill Book Co. Ltd.,.

# AN010 706L02 ADVANCED MATERIALS IN AIRCRAFT MANUFACTURING

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hour tutorial per week

Objective:

- To make students aware of different materials used inside an aircraft.

**Module-1**

Aircraft materials

Requirement of aircraft materials, property evaluation of materials for different components, classification of materials, functionality Consideration, factors influencing the selection of materials

Light weight metallic materials

Aluminium and Titanium alloys, different lightweight metals and alloys, analysis of merits and demerits of metallic materials for aircraft applications: Influence forming on material properties, strengthening mechanisms

**Module-2**

Advanced manufacturing and joining techniques for metallic materials

Casting, forging, sheet metal forming, joining techniques like mechanical fastening, welding, laser welding etc. Advanced welding processes - EBW, LBW, USW

**Module-3**

Composite materials

Classification and properties of composite materials, PMC and MMCs advantages and disadvantages of composite materials for aircraft applications Manufacturing and joining of composite materials: Preparation of PMC, MMC and laminate structures, hand layup, compression moulding, resin transfer moulding, reaction injection moulding, squeeze casting, gas pressure infiltration ,Joining of laminate structures using adhesives Design of composites for structural, wear resistance and high temperature applications.

**Module-4**

Mechanics and failure theories of composite materials: Mechanical behaviour of composite materials, laminates, fiber reinforced composites, micro mechanical behaviour of composites, different modes of failure

Non Destructive Testing (NDT) techniques and Failure analysis: Different types of NDT techniques and their application on failure analysis

**Module-5**

Micro-electro-mechanical (MEMS) systems. Introduction, characteristics of silicon wafers and other materials for MEMS applications. Various manufacturing techniques of MEMS components Materials for high temperature applications: Ni-Cr alloys, ODS materials, Ni base and Co based super alloys, carbon-carbon composites. Diffusion bond coating of high temperature materials. Powder metallurgy: Introduction and feature of powder metallurgy processes. Advanced solidification techniques: directional solidification, single crystal growth and levitation melting.

Books

1. M. F. Ashby, H. Schercliff and D. Cubon. (2007)Materials Engineering Science, Processing and Design, Butterowrth and Heinemann Publications.

2. M. J. Hinton, P. D. Soden and A.S. Kaddour. (2004) Failure Criteria in Fiber Reinforced-Polymer Composites, Elsevier.

3. Robert M. Jones. (2001) Mechanics of Composite Materials, Taylor and Francis.

4. Valery V. Vaseliev and Evgency V. Morozov. (2001) Mechanics and Analysis of Composite

Materials, Elsevier.

5. Michael Asbhy. (1999) Materials Selection in Mechanical Design, Butterworth and Heinemann

## AN 010 706L03 Failure Analysis and Design

**Teaching scheme** **Credits:** 4

2 hours lecture and 2 hours tutorial per week

***Objectives:***

- *To introduce basic concepts of reliability in analysis and design*
- *To study fracture, fatigue and other modes of failure*

**Module1 (12 hours)**

**Reliability:** Reliability concept and hazard function, life prediction, condition monitoring, application of Poisson, exponential and Weibull distribution for reliability - bath tub curve - parallel and series system - mean time between failures and life testing.

**Stresses in a body:** Two dimensional and three dimensional state of stress, Mohr's circle two and three dimensions, hydrostatic stress, Von-mises, maximum shear stress (Tresca), octahedral shear stress, torsional stresses for large plastic strain.

**Module 2 (12 hours)**

**Fracture:** Types of fracture, Griffith crack theory, stress analysis of cracks, metallographic aspects of fracture. Brittle, ductile fractures, notch effects, fracture curve, R curve, fracture under combined stresses, effect of hydrostatic pressure on fracture, probabilistic aspects of fracture mechanics, toughness of materials.

**Module 3 (12 hours)**

**Fatigue:** Statistical nature of fatigue, S-N curve, low cycle fatigue, strain life equations, structural feature of fatigue, fatigue crack propagation, effect of stress concentration, size, surface properties, metallurgical variables on fatigue, case studies, designing against fatigue, detail design, improvements after failure and service, fatigue of bolts, welded and adhesive joints.

**Fatigue tests:** Purpose, specimen, fatigue test procedures, evaluation of fatigue test results, crack growth measurement.

**Module 4 (12 hours)**

**Wear failures:** Type of wear, role of friction in wear, lubricated and non-lubricated wear, analysing wear failures, wear tests SOAP, ferrography.

**Corrosion failures:** Factors influencing corrosion failures, analysis of corrosion failures, overview of various types of corrosion, stress corrosion cracking - sources, characteristics of stress corrosion cracking, procedure of analysing stress corrosion cracking, various types of hydrogen damage failures, corrective and preventive action.

**Module 5 (12 hours)**

**Elevated temperature failures:** Creep, stress rupture, elevated temperature fatigue, metallurgical instabilities, environmental induced failure, elevated temperature effects on certain gas turbine components and petroleum refinery components, tests for analysis of failure at elevated temperatures.

**References**


1. Jaap Schijve, "Fatigue of Structures and Materials", Kluwer Academic Publishers, 2001.
2. ASM Metals Handbook, "Failure Analysis and Prevention", ASM Metals Park, USA, Vol. 10, 10th Edition, 1995.
3. Richard W Hertzberg,"Deformation and Fracture Mechanism of Engineering Materials",John Wiley & Sons,Inc.,1995.
4. George E Dieter, "Mechanical Metallurgy", McGraw Hill Book Company, 1988.

# AN 010 706 L04 Helicopter Aerodynamics

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To give students essentials of vertical and forward flight of rotary aircraft, the essentials of helicopter aerodynamics and of helicopter design.*

**Module I -**

*Helicopter Basics:-* Axes of flight, Movement about vertical, longitudinal and lateral axes.-Control Mechanism's-Directional control pedals, cyclic pitch control, collective pitch control. Articulated rotor head mechanism. Main rotor design-Diameter, Tip speeds, blade area, number of blades, Twist, Tip shape, Taper, Rotor Inertia.

**Module II -**

*Rotor mechanism in vertical flight*:- Climbs and descents, conditions of flow, climb & descent power, Vertical auto rotation. Momentum theory for hover, vertical climb and vertical descent. *Blade element theory:*-Basic method, thrust approximations, Non-uniform in flow, ideal twist, Blade mean lift co efficient and tip losses.

**Module III -**

*Rotor mechanism for forward flight:*- Edge wise rotor, Trim conditions, Blade flapping and feathering Velocity distributions, flapping blades, rotor controls equivalence of flapping feathering. *Rotor Aerodynamics in forward flight:*- Momentum theory, Blade element theory, In-plane H force.

**Module IV - *Aerodynamic Design***

Blade section design, Airfoils for rotor blades, super critical air foils, Peculiar airfoils-Blade tip shapes, parasite drag, Rear fuselage up sweep. Aerodynamic design process. *Tale rotor design:-* Diameter, Tip speed, Blade area, twist maximum pitch, pusher type & puller type, direction of rotation. NOTAR.

**Module V-**

*Performance:-* Introduction, hover and vertical flight, forward level flight, climb in forward flight, optimum speeds maximum level speed, Accurate Performance Prediction.Trim, *Stability & Control:*-Trim, Treatment of stability & Control, *Static Stability:-* Incidence disturbance, Forward speed disturbance. Angular velocity disturbance, sideslip disturbance, yawing disturbance. Dynamic stability, special cases of hover, hinge less rotor, control, and Auto Stabilization.

***References:***


(a) *Basic Helicopter Aerodynamics, IInd edition, John Seddon and Simon New man.*

(b) *Helicopter Aerodynamics by R.W Prouty, Sterling Book House.*

## AN 010 706 L05 Optimization methods in design

**Teaching scheme** **Credits:** 4

2 hours lecture and 2 hours tutorial per week

**Module 1 (12 hours)**

**Nonlinear optimization**: Introduction - one-dimensional optimization - elimination methods - unrestricted search, exhaustive scare Fibonacci and Golden section methods - Interpolation methods - quadratic and cubic interpolations, direct root methods.

**Module 2 (12 hours)**

**Unconstrained nonlinear optimization**: Direct search methods - random search methods - pattern search methods – method of rotating coordinates - descent methods - steepest descent, conjugate gradient, Quasi-Newton, and variable metric methods.

**Module 3 (12 hours)**

**Constrained nonlinear optimization**: Direct methods - the complex method, cutting plane method, methods of feasible directions - indirect methods - transformation techniques, interior and exterior penalty function methods.

**Module 4 (12 hours)**

**Non-traditional optimization**: Introduction to genetic algorithms, simulated annealing, particle swam optimization and ant colony optimization.

**Module 5 (12 hours)**

Static Applications: - Structural applications – Design of simple truss members - Design applications – Design of simple axial, transverse loaded members for minimum cost, weight – Design of shafts and torsionally loaded members – Design of springs.
Dynamic Applications:-Dynamic Applications – Optimum design of single, two degree of freedom systems.
Application in Mechanisms – Optimum design of simple linkage mechanisms.

**Text Books**


1 Singiresu S. Rao, *Engineering optimization: theory and practice,* 3rd Edition, Wiley Interscience, 1996
1. Kalyanmoy Deb, *Optimization for engineering design,* PHI, New Delhi, 2000
2. David E. Goldberg, *Genetic algorithms in search, optimization and machine learning,* Addison Wesley Pub. Co., 1989
3. Harvey M. Salkin, *Integer programming,* Addison-Wesley Pub. Co., 1975
4. Stephen C. Nash and Ariela Sofer, *Linear and nonlinear programming,* McGraw Hill College Div., 1995

**Reference Books**


1. Fred Glover, Manuel Laguna, and Fred Laguna, *Tabu search,* Kluwer Academic Publishers, 1997
2. Johnson Ray, C., "Optimum design of mechanical elements", Wiley, John & Sons, 1990.
3. Goldberg, D.E., "Genetic algorithms in search, optimization and machine", Barnen, Addison-Wesley, New York, 1989.

## AN 010 706 L06 Rotor Dynamics

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To familiarize with rotor dynamic fundamentals, rotating machinery vibrations and rotor dynamic analysis.*

**Module I – Torsional vibrations in rotating machinery**

Modeling of rotating machinery –critical speed of shafts , transfer matrix analysis of free vibrations, equivalent discrete system, excitation torque, transient response in torsional system

**Module II – Hydrodynamic bearings**

Viscosity, Mechanism of pressure development in the film, Reynold's No., Journal bearing, Steady state solution of short bearings, squeeze film bearings, and orbital motion, magnetic bearings, auxiliary bearings

**Module III – Gyroscopic effects**

Gyroscopics of a spinning disk, synchronous whirl of an overhung rotor, non synchronous whirl, rotor system with a coupling, finite element method, whirl speed analysis.

**Module IV-**

Instability in torsional vibration, Conditional Instability in torsional vibration, Instability due to fluid film forces and hystersis

**Module V**

Balancing of rigid rotors and flexible rotors, Jeffcot-rotor-Green stodola rotor- external and internal damping-condition monitoring using vibration measurements

***Reference:***

*Rotor Dynamics, J S Rao, New Age Publishers*

# AN 010 707 Experimental Stress Analysis Lab

**Teaching scheme** **Credits**: 2

3 hours practical per week

**Objectives**

- *To experimentally analyze stresses on different structures under various loads using different techniques.*

**Experiments**

1. Unsymmetric bending of beams.
2. Shear Centre location for open sections.
3. Shear Centre location for closed sections
4. Constant Strength beam.
5. Flexibility matrix for cantilever beam.
6. Beam with combined loading.
7. Calibration of Photo-elastic materials.
8. Stresses in Circular discs and beams using photoelastic techniques.
9. Vibrations of beams.
10. Wagner beams – Tension field beam.

# AN 010 708 Vibration Lab

**Teaching scheme** **Credits**: 2

3 hours practical per week

**Objectives**

- *To analyze different kinds of vibration on various materials using different apparatus.*

**Experiments:**

1. Determination of Modulus of elasticity, Rigidity Modulus, Poisson's Ratio of a material of wire – Searle's apparatus.
2. Determination of radius of gyration of the material of the bar about centroidal axis – Bar pendulum.
3. Analysis of damped vibration- viscous damper method.
4. Vibration analysis – vibration measuring instruments and cathode ray oscillograph.
5. Double pendulum.
6. Whirling apparatus critical speed of shaft of using single disc.
7. Un-damped free vibration with non linear spring forces
    - Hard spring
    - Soft Spring
8. Forced vibration experiment
9. Response to pulse input .
    - Rectangular Pulse
    - Half sinusoidal input.

## AN 010 709 Seminar

**Teaching scheme** **credits: 2**

2 hours practical per week

The seminar power point presentation shall be fundamentals oriented and advanced topics in the appropriate branch of engineering with references of minimum seven latest international journal papers having high impact factor.

Each presentation is to be planned for duration of 25 minutes including a question answer session of five to ten minutes.

The student's internal marks for seminar will be out of 50. The marks will be awarded based on the presentation of the seminar by the students before an evaluation committee consists of a minimum of 4 faculty members. Apportioning of the marks towards various aspects of seminar (extent of literature survey, presentation skill, communication skill, etc.) may be decided by the seminar evaluation committee.

A bona fide report on seminar shall be submitted at the end of the semester. This report shall include, in addition to the presentation materials, all relevant supplementary materials along with detailed answers to all the questions asked/clarifications sought during presentation. All references must be given toward the end of the report. The seminar report should also be submitted for the viva-voce examination at the end of eighth semester.

**For Seminar, the minimum for a pass shall be 50% of the total marks assigned to the seminar.**

## AN 010 710 Project Work

**Teaching scheme** **credits: 1**

1 hour practical per week

Project work, in general, means design and development of a system with clearly specified objectives. The project is intended to be a challenge to intellectual and innovative abilities and to give students the opportunity to synthesize and apply the knowledge and analytical skills learned in the different disciplines.

The project shall be a prototype; backed by analysis and simulation etc. No project can be deemed to be complete without having an assessment of the extent to which the objectives are met. This is to be done through proper test and evaluation, in the case of developmental work, or through proper reviews in the case of experimental investigations.

- The project work has to be started in the seventh semester and to be continued on to eighth semester.
- Project work is to be done by student groups. Maximum of four students only are permitted in any one group.
- Projects are expected to be proposed by the students. They may also be proposed by faculty member (Guide) or jointly by student and faculty member.
- Students are expected to finalise project themes/titles with the assistance of an identified faculty member as project guide during the first week of the seventh semester.

The progress from concept to final implementation and testing, through problem definition and the selection of alternative solutions is monitored. Students build self confidence, demonstrate independence, and develop professionalism by successfully completing the project.

Each student shall maintain a project work book. At the beginning of the project, students are required to submit a project plan in the project book. The plan should not exceed 600 words but should cover the following matters.

- ❖ Relevance of the project proposed
- ❖ Literature survey
- ❖ Objectives
- ❖ Statement of how the objectives are to be tackled

- Time schedule
- Cost estimate

These proposals are to be screened by the evaluation committee (EC- minimum of 3 faculty members including the guide) constituted by the head of department, which will include a Chairman and the EC will evaluates the suitability and feasibility of the project proposal. The EC can accept, accept with modification, request a resubmission, or reject a project proposal.

Every activity done as part of project work is to be recorded in the project book, as and when it is done. Project guide shall go through these records periodically, and give suggestions/comments in writing in the same book.

The students have to submit an interim report, along with project work book showing details of the work carried out by him/her and a power point presentation at the end of the 7th semester to EC. The EC can accept, accept with modification, request a resubmission, or extension of the project.

The student's internal marks for project will be out of 50, in which 30 marks will be based on day to day performance assessed by the guide. Balance 20 marks will be awarded based on the presentation of the project by the students before an evaluation committee consists of a minimum of 3 faculty members including the guide.

**For Project, the minimum for a pass shall be 50% of the total marks assigned to the Project work.**

## AN 010 801 Rockets and Missiles

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To familiarize students knowledge of rocket and missiles, their performance and control.*

**Module I – Flight performance of Rockets and missiles**

Gravity-free Drag-free space flight, Forces acting on a vehicle in the atmosphere, basic relations of motion, space flight, flight maneuvers, Effect of propulsion systems on vehicle performance, flight vehicles, military missiles, flight stability

**Module II – Aerodynamics of Rockets and missiles**

Airframe components of rockets and missiles force acting on a missile in atmosphere, classification of missiles, aerodynamic forces and moment, Lateral aerodynamic moment, lateral damping moment and longitudinal moment of a rocket, lift and drag forces, body up wash and down wash in missiles and rocket propulsion.

**Module III– Rocket Motion in free space and gravitational field**

One dimensional and two dimensional rocket motion in free space and homogeneous gravitational fields. Description of vertical , inclined and gravity turn trajectory, Determination of Range and altitude, simple approximation to burn out velocity.

**Module IV – Staging and control of rockets**

Rocket vehicle control methods, Thrust determination, multi staging of rocket, vehicle optimization stage separation techniques, materials used in rockets, special requirement of material to perform under adverse conditions.

**Module V – Selection of rocket propulsion systems and rocket testing methods**

Selection process, criteria for selection, types of tests, test facilities and safeguards, Instrument and data management, flight testing.

***References:***

*(a)Sutton G P – Rocket propulsion elements, John Wiley*
*(b)Parker E P – Materials of missiles and space craft, Mc graw Hill*
*(c)Philip Hill/ Petersen - Mechanics and thermodynamics of propulsion*

## AN 010 802 Introduction to Space technology

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To familiarize the students with the various design elements and problems concerned with space travel.*
- *To introduce basic mechanics involved in satellite launches, interplanetary travel and reentry.*

**Module I – Basic concepts of general n- body problem**

Solar system – reference frames, coordinate system, relation matrix, Euler's angles, spherical celestial coordinates, ecliptic motion of vernal equinox, siderial time, many body problem ,Legrange's equation, Legrange's points, Jacob's integrals circular restricted three body problem, libration points, relative motion in n body problem, Satellite orbit, relation between position and time, orbit elements,

**Module II – Fundamentals of orbital mechanics**

Two body problem- energy and angular momentum, orbit equation , Keppler's equations, escape velocity, conic section geometry , motion in elliptical , hyperbolic , parabolic orbits, basic orbital maneuvers ,

**Module III – Satellite injection and orbit transfer**

Various cases of orbit deviation due to injection errors, Special and general perturbations , Cowell's method, Enckes method, Method of vibration of orbital elements, General perturbation approach,

**Module IV – Interplanetary trajectory**

Two dimensional interplanetary trajectories , fast interplanetary trajectories, three dimensional interplanetary trajectories , launch windows and mission duration , departure and arrival , planetary fly by optimal planetary capture ,

**Module V – Entry Flight Mechanics**

Rocket propulsion fundamentals , Atmospheric entry, Entry heating, altitude determination and controls , review of rotational dynamics, disturbance torque, passive altitude control, active control, thermal control, spacecraft control, telecommunication

***References:***


i) *Ashish Tewari, Atmospheric and space Flight dynamics., Springer*
ii) *William E Wiesel , Space flight dynamics, Mc Graw Hill*
iii) *Vandekamp P , Elements of astromechanics, Pitman*
iv) *Cemmelisse J W , Rocket propulsion and space dynamics, W H Freeman*
v) *Sutton, Rocket propulsion, Mc Graw Hill*

## AN 010 803 Air transportation and Aircraft Maintenance

**Teaching scheme** **Credits**: 4
2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To familiarize students with various aspects of aviation industry including airline economics, operations and maintenance.*

**Module I - INTRODUCTION**

Development of air transportation, comparison with other modes of transport - Role of IATA, ICAO – The general aviation industry airline - Factors affecting general aviation, use of aircraft, airport: airline management and organisation - levels of management, functions of management, Principles of organisation planning the organisation - chart, staff departments & line departments.

**Module II - AIRLINE ECONOMICS**

Forecasting - Fleet size, Fleet planning, the aircraft selection process, operating cost, passenger capacity, load factor etc. - Passenger fare and tariffs - Infuence of geographical, economic & political factors on routes and route selection.
FLEET PLANNING: The aircraft selection process - Fleet commonality, factors affecting choice of fleet, route selection and Capitol acquisition - Valuation & Depreciation - Budgeting, Cost planning - Aircrew evaluation -Route analysis - Aircraft evaluation.

**Module III - PRINCIPLES OF AIRLINES SCHEDULING**

Equipment maintenance, Flight operations and crew scheduling, Ground operations and facility limitations equipments and types of schedule - hub & spoke scheduling, advantages / disadvantages & preparing flight plans- Aircraft scheduling in line with aircraft maintenance practices.

**Module IV - AIRCRAFT RELIABILITY**

Aircraft reliability - The maintenance schedule & its determinations - Condition monitoring maintenance - Extended range operations (EROPS) & ETOPS - Ageing aircraft maintenance production.

**Module V - TECHNOLOGY IN AIRCRAFT MAINTENANCE**

Airlines scheduling (with reference to engineering) - Product support and spares - Maintenance sharing - Equipments and tools for aircraft maintenance - Aircraft weight control - Budgetary control.On board maintenance systems - Engine monitoring - Turbine engine oil maintenance - Turbine enginevibration monitoring in aircraft - Life usage monitoring - Current capabilities of NDT - Helicopter miantenance -Future of aircraft maintenance.
Total No of periods: 45

***References:***

*(a) Fedric J.H., " Airport Management ", English Book House, New Delhi-I.*
*(b) Gene Krope, " Airline Procedures ", English Book House, New Delhi-I.*

*(c) Wilson & Bryon, " Air Transportation ", English Book House, New Delhi-I.*
*(d) Philip Lockin D, " Economics of Transporation ", English Book House, New Delhi-I.*
*(e) " Indian Aircraft manual ", Published by DGGA, English Book House, New Delhi-I.*
*(f) Alexander T Wells, " Air Transporation ", Wadsworth Publishing Company, California, 1993.*
*(g) C.H. Friend, " Aircraft Maintenance Management ", English Book House, New Delhi-I*

## AN 010 804 L01 Project Management And Total Quality Management

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To introduce students best practices in improving quality, quality management principles and various quality management tools.*
- *To familiarize students with various quality systems used such as ISO.*

**Module I – INTRODUCTION**

Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs - Analysis Techniques for Quality Costs, Basic concepts of Total Quality Management, Historical Review,Principles of TQM, Leadership – Concepts, Role of Senior Management, Quality Council,Quality Statements, Strategic Planning, Deming Philosophy, Barriers to TQM Implementation.

**Module II – TQM PRINCIPLES**

Customer satisfaction – Customer Perception of Quality, Customer Complaints, Service Quality,Customer Retention, Employee Involvement – Motivation, Empowerment, Teams, Recognition and Reward, Performance Appraisal, Benefits, Continuous Process Improvement – Juran Trilogy,PDSA Cycle, 5S, Kaizen, Supplier Partnership – Partnering, sourcing, Supplier Selection,Supplier Rating, Relationship Development, Performance Measures – Basic Concepts, Strategy,Performance Measure.

**Module III – STATISTICAL PROCESS CONTROL (SPC)**

The seven tools of quality, Statistical Fundamentals – Measures of central Tendency and Dispersion, Population and Sample, Normal Curve, Control Charts for variables and attributes,Process capability, Concept of six sigma, New seven Management tools.

**Module IV – TQM TOOLS**

Benchmarking – Reasons to Benchmark, Benchmarking Process, Quality Function Deployment(QFD) – House of Quality, QFD Process, Benefits, Taguchi Quality Loss Function, Total Productive Maintenance (TPM) – Concept, Improvement Needs, FMEA – Stages of FMEA.

**Module V – QUALITY SYSTEMS**

Need for ISO 9000 and Other Quality Systems, ISO 9000:2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits.

***References:***

*1. Dale H.Besterfiled, et at., Total Quality Management, Pearson Education Asia, 1999. (Indian reprint 2002).*

*REFERENCES:*

*2. James R.Evans & William M.Lidsay, The Management and Control of Quality, (5th Edition), South-Western (Thomson Learning), 2002 (ISBN 0-324-06680-5).*

*3. Feigenbaum.A.V. "Total Quality Management, McGraw-Hill, 1991.*
*4. Oakland.J.S. "Total Quality Management Butterworth – Hcinemann Ltd., Oxford. 1989.*
*5. Narayana V. and Sreenivasan, N.S. Quality Management – Concepts and Tasks, New Age International 1996.*
*6. Zeiri. "Total Quality Management for Engineers Wood Head Publishers, 1991.*

## AN 010 804L02 Air Navigation

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To introduce students with basic terminologies used in navigation of aircraft.*
- *To familiarize students with various navigational methods and systems used in different phases of flight.*

**Module I**

(a) Form of the Earth, Linear Distance and Departure --Introduction, The earth's size and shape, The geographic poles, Properties of a great circle, Describing positions on the earth, Spacing of meridians, GC tracks and distances on the earth, Geographic / Geodetic and geocentric latitudes, Kilometers , Statute mile, Comparison of units of length.

(b) The Velocity Triangle--Introduction, Speed and velocity, True airspeed (TAS), The velocity triangle, The aircraft velocity triangle , Drift, Finding heading and ground speed, Wind components, True wind components, Effective wind components, Effective along track wind component with wind at 900 to track.

(c) Temperatures, Airspeeds and Altitudes--Introduction, Static air temperature (SAT), Effects of compressibility on air temperature measurement, Total air temperature (TAT) , Ram air temperature (RAT) , Obtaining the COAT, Airspeeds, Density correction when TAS in under 300kt and using navigational circular slide rule (CSR) , Using airspeed correction scale when TAS is over 300 knots, Obtaining TAS from Mach Number, Altitudes and pressure settings, Altimeter settings.

**Module II**

(a) DR Navigation--Introduction, Mental estimation of head/tailwind components and drift, Mental estimation to revise estimated times of arrival (ETAs), Findings an approximate DR position, Finding DR position with a tack plot, Factors affecting accuracy of DR positions, Resolving DR error, Minimizing fix errors, Plotting on various charts.

(b) Maximum Range, Radius of Action and Point of No Return--Introduction, Still air range (SAR), Radius of action (R of A) or point of no return (PNR), When PNR is required, Calculating PNR by simple formula, Calculating PNR with engine failure, Tabular solution to the PNR, PNR in still air, PNR in wind conditions, Effect of endurance on PNR distance , Effect of performance on PNR distance.

(c) Point of Equal Time or Critical Point --Introduction, The point of equal time (PET) , Importance, Engine failure PET, Still air PET, The effect of along track wind components, PET Formula, Calculating ETA at cirtical points, Calculating PET for engine Failure, Effect of reduced TAS on PET ,The PET compared with the PNR, Relationship between the PET and PNR.

**Module III - Visual Navigation**

Introduction, Map Reading, Useful checkpoints, Identifying a checkpoint (pinpoint), Special uses of line features, Lines of Position (LOP) , Doubling the angle on the bow, A running fix, Assessing distance away from an aircraft, Type of terrain, Mountainous areas, The effect of the seasons, Inadequately mapped areas, Effect of times of the day on map reading, Procedure when lost, Orientation of maps.

**Module IV--Navigation in Climb and Descent**

Introduction, Obtaining a mean TAS for the climb, Obtaining the correct mean TAS for a climb, Obtaining the Mean TAS for climbs from Higher levels, Obtaining the mean W/V for a climb, obtaining the DR position at the top of climp (TOC), Establishing TOC position, Navigation on the descent, W/V for the descent, Obtaining the DR position for the top of descent (TOD), Fixing position at the TOD, Obtaining climb and descent gradients, Relationship between vertical speed, GS and angle of climb / descent, The importance of an accurate position at TOD.

**Module V - Inertial Navigation Systems (INS)**

Introduction, The principle of the INS, Inertia, Accelerometers, Integrators, Using two accelerometers, The stable platform , The structure of the stable platform, The operation of the system, The Inertial Navigation Unit (INU) , keeping the platform level, Allowing for altitude, Initial alignment , Pre-departure Procedure, In-Flight Presentations, Action at waypoints, Errors of the INS, Strapdown systems, Ring laser gyros (RLG) , Connection of INS to other aircraft systems, Checking inertial presentation.

***Reference:***

*(a)Air Navigation, C W Martin*

## AN 010 804 L03 Aircraft Rules and Regulations

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To impart knowledge of various rules and regulations governing the civil aviation in India.*

**MODULE I - The Aircraft Rules, 1937**

Definitions and interpretations, Rules 5, Rule 7, 7A & 7B, Rule 15, Rule 25 A, Rule 30, Rule 49 ,Rule 50, Rule 55, and Rule 61.

**MODULE II - CAR Series -A, Band C**

CAR series A-procedure for Civil Airworthiness requirements, and responsibility of operators vis-à-vis Airworthiness directorate: Responsibility of operators/ owners, procedure and CAR issue, amendments etc., objectives and targets of Airworthiness directorate. CAR series B:- Preparation of MEL, and its approval, preparation and use of cock pit check list and Emergency check list.CAR Series C: Defect recording, reporting, investigation, rectification and analysis. Analytical study of in flight instrument reading and recording. Maintenance control by reliability method.

**MODULE III - CAR Series D,E and F**

Car series D:- Aircraft Maintenance Programs, reliability program (Engines), Aircraft Maintenance program and their approvals. TBO- revision program-reciprocating engines. CAR Series E: - Approval of organizations in categories A,B,C, D, E, F & G, release and rejection notes. CAR Series F:- Procedure relating to registration & Aircrafts, issue, validation and renewal of certificate Of Airworthiness, procedure for issue, revalidation of type certificate of Aircraft and its engines.

**MODULE IV - CAR series L, M, T and X**

CAR Series L- Issue of AME License, its classification, experience requirements, issue of BAMEC and its classifications. CAR Series T & X:- Flight testing of series of Aircraft for issue of COA, Registration Markings & Aircraft, weight & balance control, provision of First aid kit and physician's kit, documents to be carried on board on Indian registered aircraft. Aircraft log books.

**MODULE V - CAR 21**

Sub part B, Application for a type certificate & its procedures, sub part G- production organization approval, sub part I-Noise certificate, subpart JA- Design organization approval, subpart L-Export Airworthiness approvals, Sub part O- Indian Technical Standard Order (ITSO)

***References:-***

*(a) Aircraft Manual (India) Volume I-Sterling Book House*

*(b) Civil Aviation Requirements-section 2-Airworthiness Volume I & II. Issued by DGCA- English Book Store, New Delhi*

*(c) CAR 21-issued by DGCA*

# AN 010 804L04 INDUSTRIAL AERODYNAMICS

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hour tutorial per week

Objective:

- *To make students aware of various atmospheric changes and its effect in flight vehicles.*
- *Also to plot out the trajectory of Aerodynamics on each structure.*

MODULE-1: ATMOSPHERE

Types of Winds, Causes of variation of winds, Atmospheric Boundary layer, Effect of terrain, Gradient height, Structure of Turbulent flows.

MODULE-2: WIND ENERGY COLLECTORS

Horizontal and vertical axis machines, Power coefficient, Betz coefficient by momentum theory. Basic shape factors, bluff body aerodynamics, Wind tunnels and measurement techniques

MODULE-3: VEHICLE AERODYNAMICS

Power requirements and Drag coefficients of Automobiles, Effects of cut back angle, Aerodynamics of trains, Aerodynamics of Hovercraft. Dynamic effects, aeroelastic phenomena, Application to buildings, chimneys, towers, bridges, automobiles, etc.

MODULE-4 BUILDING AERODYNAMICS

Pressure distribution on low rise buildings, Wind forces on buildings, Environmental winds on City blocks, Special problems of Tall buildings, Building codes, building ventilation and Architectural aerodynamics.

MODULE-5 FLOW INDUCED VIBRATION

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

References:

1. Scorer, R.S.," Environmental aerodynamics " , Ellis Harwood Ltd., England, 1978.

2. Sovran, M., " Aerodynamic Drag Mechanisms of Bluff Bodies and Road Vehicles " , Plenum Press, N.Y.,

1978.

3. Sachs. P., " Wind Forces in Engineering ", Pergamon Press, 1988.

4. Blevins, R.D., " Flow Induced Vibrations ", Van Nostrand, 1990.

5. Calvert, N.G., " Wind Power Principles", Charles Griffin & Co., London, 1979

## AN 804 L05 Acoustic and Noise Control

**Teaching scheme** **Credits:** 4

2 hours lecture and 2 hours tutorial per week

***Objectives:***

- *Elementary physical acoustics in 1D and its extension to simple 3D situations*
- *The significance of human factors in acoustics*
- *Fundamentals of architectural acoustics and noise control*

**Module1 (12 hours)**

Longitudinal wave propagation in a rod-Derivation of wave equation-Physical interpretation of the wave equation solution-One Dimensional Waves in a Gas-Acoustic Energy and Acoustic Intensity-Energy in a plane progressive wave-Acoustic Impedance

**Module 2 (12 hours)**

Sound Perception and the Decibel Scale-The ear-The decibel Scale-Combining Sound Levels in Decibels-Octave Bands-Loudness-The "A" Weighting-Legal requirements for noise control

**Module 3 (12 hours)**

Acoustic Resonance-Resonance of a pipe closed at both ends-Resonance of a pipe closed at one end, open at the other-Reflection & Transmission of Plane Acoustic Waves-Sound Transmission through layers and partitions-Transmission through a layer-Transmission through solid partitions

**Module 4 (12 hours)**

Room Acoustics-Acoustic Absorption-Reverberation Time-Sound Transmission between Rooms

The wave equation in 3 dimensions-Acoustic impedance of a spherical wave - near and far field effects-Source efficiency

**Module 5 (12 hours)**

Directionality of acoustic sources and receivers-Directivity index-Screens-Silencers Helmholtz resonator design-Expansion chamber silencer design-Dissipative silencers Active control of noise

**References**


1. Turner and Pretlove, Acoustics for Engineers, Macmillan, 1991
2. Kinsler, Frey, Coppens & Sanders. Fundamentals of Acoustics. 3rd Edition. John Wiley, 1982
3. Smith, Peters and Owen, Acoustics and Noise Control, Addison-Wesley-Longman, 2nd edition 1996
4. Bies and Hanson, Engineering Noise Control, theory and practice E&FN Spon, 2nd edition, 1996

## AN010 804 L06 Transport process on Reacting Flows

**Teaching scheme** **Credits**: 4
2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To impart knowledge of principles of reacting flows based on thermodynamics, kinetics and transport.*
- *To give an understanding of dynamics of reacting flows based on the principles of heat, mass and momentum transfer including an introduction to combustion chemistry.*

**Module I – Principles of heat transfer**
Conduction-basic concepts-steady state one dimensional-steady state two dimensional and three dimensional-unsteady heat conduction
Convection-introduction to hydrodynamics-dimensional analysis-forced and free convection
Radiation-basic relation-thermal radiation

**Module II – Mass and Momentum transfer**
Elements of mass diffusion
Heat and mass transfer
basic concept-diffusion mass transfer-frick s law of diffusion-steady state molecular diffusion-convective mass transfer-momentum,heat and mass transfer analogy-convective mass transfer correlations

**Module III**
Chemical Kinetics, and equilibrium reaction kinetics, reactive collision potential, activation energy. The collision process, fast reaction – relaxation process. Chemical equilibrium dependence of equilibrium constant with temperature effect of condension on equilibrium calculation of exploration temperature

**Module IV – Reactive Gas dynamics**
General equations for reactive gas dynamics, approximations to general equations laminar flow, compressible inviscid reactive gas dynamics steady one dimensional inviscid flow. Quasi one dimensional inviscid flow . Non steady one dimensional inviscid flow, turbulence on a homogeneous fluid. Turbulent mixing with reaction

**Module V - Combustion chemistry**
Adiabatic thermal explosion, vessel explosion, thermal combustion chemistry, chain reaction, vessel explosion branching chain unfied theory of vessel explosion, flame temperature and burning velocity, laminar theory ionization in flame, laminar flame holding laminar flame shape, turbulent get diffusion flame extinction of diffusion flames, flammability limb

***Reference:***

*(a)Heat and Thermodynamics, Zemansky*
*(b)Physical Chemistry, Gladston*
*(c)Combustion fundamental, Royer A Strehlow, Mc Graw Hill.*
*(d)Chemical Engineering, Juliust Banchero , Tata Mc Graw Hill.*

## AN 010 805 G01 Boundary layer Theory

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To cover fundamentals of viscous flow.*
- *To understand, analyze and formulate equations for laminar, transition and turbulent boundary layers including a study of numerical methods used to solve the governing equations.*

**Module I -Viscous flow and fundamentals of boundary layer theory**

Viscosity- Reynold's No. – Laminar and turbulent flow, boundary layer concept- Laminar boundary layer on a flat plate at zero incidence, turbulent boundary layer at zero incidence, boundary layer on an aerofoil separation of boundary layer.

**Module II – Laminar boundary layer**

Boundary layer equation in plane flow, setting up of boundary layer equation, wall friction, separation and displacement, dimensional representation of the boundary layer equation, friction drag, plate boundary layer, general properties of boundary layer equation , their solutions, Derivation of ordinary differential equation of a) boundary layer with outer flow, b) boundary layer without outer flow, wedge flow, flow in a convergent channel, mixing layer, moving plate, free jet, wall jet .

**Module III – Laminar Turbulent transition**

Some experimental results on the laminar turbulent transition – Transition in pipe flow, transition in boundary layer,- fundamentals of primary stability theory, Orr- sommerfield equation curve of neutral stability, and the indifference Reynold's no. plate boundary layer , effect of pressure, gradient effect of suction, effect of compressibility, effect of wall roughness, - Instability of boundary layer of three dimension – boundary layer at curved wall, boundary layer at rotating disc.

**Module IV – Turbulent boundary layer**

Fundamentals of turbulent flows- basic equations for the mean motion of turbulent flows – continuity equation ,momentum equation , equations for kinetic energy of turbulent fluctuations, Thermal energy equation- Description of turbulent fluctuations, correlations, spectra and eddies turbulent of outer flows, Internal flow - Couette flow, Two layer structure of the velocity flow, universal laws of the wall, friction law, turbulence models , heat transfer, fully developed internal flows, channel flow, coutte – poiseuille's flow, pipe flow

**Module V – Numerical methods in boundary layer theory**

Numerical integration of the boundary layer- Note on boundary layer transformations- explicit and implicit discretisation, solution of implicit difference equation, Integration of continuity equation, boundary layer edge and wall shear stress, Integration of

transformed boundary layer using box scheme, Turbulent boundary layer method of wall function

***Reference:***


*(a) A Schlitching K Gersten , Boundary Layer theory, Mc Graw Hill*

*(b) J D Anderson, Fluid mechanics , Mc Graw Hill*

## AN 010 805 G02 Disaster Management

**Teaching scheme** **Credits:** 4

2 hours lecture and 2 hours tutorial per week

**MODULE 1 (12 hours)**

Importance of disaster management - Types of emergencies – major industrial disasters – Components of a major hazard control system – identification of major hazard control installations – purpose and procedures – safe operation of major hazard installations – mitigation of consequences – reporting to authorities. Implementation of major hazard control systems – group of experts – training – checklists – inspection – evaluation of major hazards – information to the public – manpower requirements – sources of Information

**MODULE 2 (12 hours)**

Emergency planning – On-site emergency planning – formulation of the plan and emergency services – Identification of resources – actions and duties – emergency procedure – mock drills. Off-site emergency planning – objectives and elements of off-site plan – role of administrative machinery – role of major hazard works management – role of the local authority. Emergency preparedness at local level – Awareness and preparedness for emergencies at local level (APELL) – The process and its partners.

**MODULE 3 (12 hours)**

Requirements of emergency plan as per Indian legislations like Factories Act, Manufacture, Storage and Import of Hazardous Chemicals Rules, Chemical Accidents (Emergency planning, Preparedness and Response) Rules-Applications of remote sensing and GIS in disaster management

**MODULE 4 (12 hours)**

Emergency planning and preparedness in international standards like ISO 14001, OHSAS 18001 and OSHA's Process Safety Management System, Emergency Planning in Seveso II directive – elements of emergency planning in IS : 18001 – Hazardous Materials / Spills Emergencies – contingency plans for road transportation of hazardous chemicals – contingency plans for oil spills in marine environment.

**MODULE 5 (12 hours)**

Natural Hazards – potentially hazardous natural phenomena – earthquakes – landslides – flooding – cyclones – hazards in arid and semi-arid areas – nature of the hazard – hazard management activities – disaster mitigation – natural hazard prediction – emergency preparedness – disaster, rescue and relief – post disaster rehabilitation and reconstruction – education and training activities – vulnerable elements to be considered in the development planning for natural hazard management .

**TEXT BOOKS:**

1. Petak, W.J and Atkisson, A.A.: *Natural Hazard Risk Assessment and Public Policy:*
*Anticipating the Unexpected*

2. Frank P Lees, '*Loss prevention in process industries*', Vol I, II, III, Butterworth, London, 1980

**REFERENCES:**


1. ILO, Geneva: *Major Hazard Control – a Practical Manual.*
2. UNEP, Paris : *APELL - A Process for responding to technological accidents , A Handbook,* Industry & Environment Office., 1998
3. *Accident Prevention Manual for Business and Industry, Vol. I* – National Safety Council, USA.
4. *Oil spill Response : The National Contingency Plan* - Institute of Petroleum, London
5. U.R. Rao : *Space Technology for Sustainable Development*

## AN 010 805 G03 Cryogenics

**Teaching scheme** **Credits: 4**

3 hours lecture and 1 hour tutorial per week

**Objectives**

- *To impart the basic concepts of Cryogenic Engineering*
- *To provide the learner with the fundamental knowledge about the properties of cryogenic materials, its storage and transfer systems*
- *To develop an understanding of various cryogenic liquefaction and refrigeration systems and their performances*

**Module 1 (8 hours)**

Introduction: Historical development- application of cryogenics -present areas involving cryogenic engineering-cryogenics in space technology- cryogenics in biology and medicine- superconductivity applications.

**Module 2 (12 hours)**

Basic thermodynamics applied to liquefaction and refrigeration process – isothermal, adiabatic and Joule Thomson expansion process -efficiency to liquefaction and coefficient of performances- irreversibility and losses. Low temperature properties of engineering materials: mechanical properties – thermal properties -electrical and magnetic properties. Properties of cryogenic fluids- superconductivity and super fluidity - materials of constructions for cryogenic applications.

**Module 3 (15 hours)**

Gas liquefaction systems: Production of low temperatures – general liquefaction systems- liquefaction systems for neon, hydrogen and helium.

**Module 4 (15hours)**

Cryogenic refrigeration systems: ideal refrigeration systems- refrigerators using liquids and gases as refrigerants- refrigerators using solids as working media - adiabatic demagnetization method.

**Module 5 (10 hours)**

Cryogenic storage and transfer systems: Cryogenic fluid storage vessels- cryogenic fluid transfer systems-cryo pumping.

**Text Books**


1. Barron R., *Cryogenic Systems*, Oxford Science Publications
2. Scott R.B., *Cryogenic Engineering*, Van Nostrand Co.


**Reference Books**


1. Mamata Mukhopadyay., *Fundamentals of Cryogenic Engineering*, PHI Learning
2. Haseldon G.G., *Cryogenic Fundamentals*, Academic Press
3. Flynn T.M., *Cryogenic Engineering*, Marcel Dekker.

## AN010 805 G04 Advanced strength of materials

**Teaching scheme** **Credits:** 4

2 hours lecture and 2 hour tutorial per week

**Objectives**

- *To analyse the stresses and deformations through advanced mathematical models.*
- *To estimate the design strength of various industrial equipments.*

**Module 1 ( 12 -hours)**

**ANALYSIS OF PLATES** Mathematical modeling of plates with normal loads – Point and Distributed Loads – Support conditions – Rectangular plates - Stresses along coordinate axes – Plate deformations – Axi-symmetric plates – Radial and tangential stresses – plate deflections.

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**Module II ( 14-hours)**

**THICK CYLINDERS AND SPHERES** Equilibrium and compatibility conditions - Lame's Theorem – Boundary conditions – distribution of radial and tangential stresses – compound cylinders – Interference fits - Stresses due to temperature distributions. piston, oscillating motor-characteristics.

**Module III ( 12 -hours)**

**ROTATING DISCS** Lame-Clayperon Theorem – radial and tangential stresses in discs due to centrifugal effects – boundary conditions – solid and hollow discs – Interference fit on shafts – Strengthening of the hub – residual stresses – Autofrettege – Discs of variable thickness – Disc profile for uniform strength.

**Module IV ( 12 - hours)**

**BEAMS ON ELASTIC FOUNDATION** Infinite beam subjected to concentrated load – Boundary Conditions – Infinite beam subjected to a distributed load segment – Triangular load – Semi infinite beam subjected to loads at the ends and concentrated load near the ends – Short beams.

**Module V ( 10 - hours)**

**CURVED BEAMS AND CONTACT STRESSES** Analysis of stresses in beams with large curvature – Stress distribution in curved beams – Stresses in crane hooks and C clamps – Contact Stresses – Hertz equation for contact stresses – applications to rolling contact elements.



**Text Books**

1. Boresi A.P., Schmidt R.J., "Advanced Mechanics of Materials", John Wiley and Sons, Sixth edition, 2003.
2. Dally J.W. and Riley W.F, "Experimental Stress Analysis", John Wiley and Sons 2003

**Reference Books**

1. Burr A. H., CheathAm J.B., "Mechanical Analysis and Design", Prentice Hall of India, Second edition, 2001.
2. Den-Hartog J.P., "Strength of Materials", John Wiley and Sons..

# AN 010 805 G05 HIGH TEMPERATURE GAS DYNAMICS

**Teaching scheme** **Credits**: 4

2 hours lecture and 2 hours tutorial per week

**Objectives**

- *To give conceptual understanding of equilibrium and non-equilibrium processes in a gas (energy exchange between molecules) and their effect on macroscopic flow of gases.*

**Module I – INTRODUCTION (10)**

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.

**Module II – STATISTICAL THERMODYNAMICS (10)**

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

**Module III – KINETIC THEORY AND HYPERSONIC FLOWS (12)**

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.

**Module IV – INVISCID HIGH TEMPERATURE FLOWS (14)**

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.

**Module V – TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES (14)**

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.

***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*

## AN010 805 G06 Turbo machines

**Teaching scheme** **Credits:** 4

2 hours lecture and 2 hour tutorial per week

**Objectives**

- *To impart the basic concepts of various turbo machines like blowers, fans, compressors and turbines.*

**Module I (12 hours)**

**Principles:** Energy transfer between fluid and rotor, classification of fluid machinery, dimensionless parameters, specific speed, applications, stage velocity triangles, work and efficiency for compressors and turbines.

**Module II (12 hours)**

**Centrifugal Fans and Blowers:** Types, stage and design parameters, flow analysis in impeller blades, volute and diffusers, losses, characteristics curves and selection, fan drives and fan noise.

**Module III (12 hours)**

**Centrifugal Compressor:** Construction details, types, impeller flow losses, slip factor, diffuser analysis, losses and performance curves.

**Module IV (12 hours)**

**Axial Flow Compressor:** Stage velocity triangles, enthalpy-entropy diagrams, stage losses and efficiency, work done factor, simple stage design problems and performance characteristics.

**Module V (12 hours)**

**Axial and Radial Flow Turbines:** Stage velocity diagrams, reaction stages, losses and coefficients blade design principles, and testing and performance characteristics.

**Text Books**

1) Yahya, S.H., *Turbines, Compressor and Fans*, Tata Mc Graw Hill Publishing Company, 1996.

2) B K Venkanna, *Fundamentals of Turbomachinery,* Prentice Hall of India, 2009

**Reference Books**

1. Bruneck, *Fans*, Pergamom Press, 1973.

2. Earl Logan, Jr., *Hand book of Turbomachinery*, Marcel Dekker Inc., 1992.

3. Dixon, S.I., *Fluid Mechanics and Thermodynamics of Turbomachinery*, Pergamom Press, 1990.

4. Shepherd, D.G., *Principles of Turbomachinery*, Macmillan, 1969.

5. Stepanff, A.J., *Blowers and Pumps*, John Wiley and Sons Inc., 1965

6. Ganesan .V. *Gas Turbines*, Tata Mcgraw Hill Pub.Co., New Delhi, 1999.

# AN 010 806 Aerodynamic Lab

**Teaching scheme** **Credits:** 2

3 hours practical per week

**Objectives**

- *To study experimentally the flow properties over various bodies by finding the pressure distribution and from which Lift, Drag and various moments are calculated.*

**Experiments:**

1. Measurement of centre of pressure and keep them in centre of pressure position.
2. Study of pressure distribution over circular cylinders.
3. Study of pressure distribution over symmetric airfoils.
4. Study of load distribution on a given wing.
5. Study of flow over a flat plate at different angle of incidence.
6. Study of pressure distribution over thin airfoils.
7. Flow studies in low speed flows over cylinders.
8. Experiment that shows the real flow field around a slender delta wing showing vortex structure and surface flow pattern.
9. Estimation of lift, drag and pitching moment by knowing pressure distributions.
10. Study of live aircraft (Piston Engine).
11. Study of Jet plane.
12. Study of Helicopter.

## AN010 807 Project Work

**Teaching scheme** **credits: 4**

6 hours practical per week

The progress in the project work is to be presented by the middle of eighth semester before the evaluation committee. By this time, the students will be in a position to publish a paper in international/ national journals/conferences. The EC can accept, accept with modification, and request a resubmission.

The progress of project work is found unsatisfactory by the EC during the middle of the eighth semester presentation, such students has to present again to the EC at the end of the semester and if it is also found unsatisfactory an extension of the project work can be given to the students.

**Project report:** To be prepared in proper format decided by the concerned department. The report shall record all aspects of the work, highlighting all the problems faced and the approach/method employed to solve such problems. Members of a project group shall prepare and submit **separate** reports. Report of each member shall give details of the work carried out by him/her, and only summarise other members' work.

The student's sessional marks for project will be out of 100, in which 60 marks will be based on day to day performance assessed by the guide. Balance 40 marks will be awarded based on the presentation of the project by the students before an evaluation committee.

**For Project, the minimum for a pass shall be 50% of the total marks assigned to the Project work.**

## AN010 808 Viva -Voce

**Teaching scheme** **credits: 2**

A comprehensive oral Viva-voce examination will be conducted to assess the student's intellectual achievement, depth of understanding in the specified field of engineering and papers published / accepted for publication etc. At the time of viva-voce, certified bound reports of seminar and project work are to be presented for evaluation. The certified bound report(s) of educational tour/industrial training/ industrial visit shall also be brought during the final Viva-Voce.

An internal and external examiner is appointed by the University for the Conduct of viva voce University examination.

**For Viva-voce, the minimum for a pass shall be 50% of the total marks assigned to the Viva-voce.**

*Note: If a candidate has passed all examinations of B.Tech. course (at the time of publication of results of eighth semester) except Viva-Voce in the eighth semester, a re-examination for the Viva-Voce should be conducted within one month after the publication of results. Each candidate should apply for this 'Save a Semester examination' within one week after the publication of eighth semester results.*