## JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

| IV Year B.Tech. AE-II Sem | L | T/P/D | C |
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### (A82129) AVIONICS AND INSTRUMENTS & SYSTEMS

**Objective:** *To introduce to the student the Avionics and instruments systems installed on aircraft.*



**UNIT– I**

**Avionics- Introduction- Avionics Standards:** Importance and role of Avionics in modern aircraft– core avionics systems and interface with pilot – aircraft state sensor systems, outside world sensor systems – task automation systems. Requirements of avionics equipment and systems– environmental, weight, reliability.

Standardisation and specifications of avionics equipment and systems- the ARINC and MIL specifications. Electrical and optical data bus systems – Integrated modular avionics architectures – avionics packaging.

**UNIT– II**

**Displays- Man Machine Interaction and Communication Systems:** Introduction to aircraft displays – head-up displays (HUD) – basic principles. Helmet mounted displays, head tracking systems. Head down displays – civil cockpit, military cockpit. Solid state standby display systems. Data fusion in displays – intelligent display management systems.

Introduction to voice and data communication systems - HF, VHF, UHF and satellite communications - Data recorders – Audio management systems – In-flight entertainment systems – ACARS data communication systems.

**UNIT– III**



**Inertial Sensors and Global Positioning Systems:** Basic principles of gyroscopes and accelerometers – Angular momentum gyros – dynamically tuned gyro – micro machined vibrating mass rate gyro. Introduction to optical gyroscopes– ring laser gyros- principles. Specific force measurements with accelerometers – spring restrained pendulous accelerometers, torque balance pendulous accelerometers. Stable platform systems– strap down systems– errors in inertial systems and compensations.

Global Navigational Satellite Systems- the Global Positioning System (GPS)– description and basic principles– integration of GPS and INS– differential GPS– augmented satellite navigation systems.

**UNIT– IV**

**Navigation, Ranging and Landing Systems:** Introduction and basic principles of navigation– types of navigation systems– Radio-navigation systems- VHF omni-range, distance measuring equipment, automatic direction finders. Attitude and heading reference systems. Inertial Navigation Systems (INS) - platform axes– angular rate corrections, acceleration correction, initial alignment and gyro compassing- strap-down INS computing. Aided INS- Kalman filters.

Landing systems– localiser and glide-slope- marker systems. Categories of instrument landing systems.

**UNIT– V**

**Surveillance Systems and Autoflight Systems:** Traffic alert and collision avoidance systems (TCAS) – Enhanced ground proximity warning systems – Air traffic control systems – Mode S transponders – Predictive wind shear warning systems – Weather radar systems – Enhanced Ground Proximity warning systems.

Longitudinal and lateral control and response of aircraft- powered flight controls- auto-stabilisation systems. Autopilots – principles- height control – heading control – ILS coupled autopilot control – automatic landing systems – satellite landing guidance systems – speed control and auto throttle control systems. Flight management systems – principles- flight planning – navigation and guidance – flight path optimization and performance prediction – cost index.

**TEXT BOOKS**



1. Collinson, R.P.G., *Introduction to Avionics Systems*, second edition, Springer, 2003, ISBN 978-81-8489-795-1

2. Moir, I. and Seabridge, A., *Civil Avionics Systems,* AIAA Education Series, AIAA, 2002, ISBN 1-56347589-8.

3. Moir, I., Seabridge, A. & Jukes, M., *Military Avionics Systems (Aerospace)*, Wiley, 2006, ISBN 9780470016329.

**REFERENCES**

1. Tooly, Mill and Wyatt, David, *Aircraft Communication and Navigation Systems,* ELSEVIER, 2007, ISBN 978-0-7506-81377.

2. Kayton, M., & Fried, W.R., *Avionics Navigation Systems,* Wiley, 1997, ISBN 0-471-54795-6.

3. Helfrick, A., *Principles of Avionics, Avionics Communications,* Inc. Leesburg, 2000, VA 20177, USA, ISBN 1-885544-10-3.

4. Moir, I. and Seabridge, A., *Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration,* AIAA Education Series, AIAA, 2001, ISBN 1-56347506-5.

5. Harris, D., *Ground Studies for Pilots: Flight Instruments and Automatic Flight Control Systems*, sixth edition, Blackwell Science, 2004, ISBN 0-632-05951-6.

6. Pallett, E.H.J., *Aircraft Instruments & Integrated Systems,* 1996, Longman Scientific & Technical.

**Outcome:** *The student would gain an understanding of the basic principles of the above systems and their application in the operation of aircraft.*

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## (A82127) AIRPORT PLANNING AND OPERATIONS

**(Elective- III)**

**Aim:** *To introduce to the student the* airport planning and operations.

**UNIT- I**

**Airport as an Operational System:** Private airports and public use airports, commercial service airports and primary commercial service airports, general aviation airports, reliever airports. Hub classification- large hubs, medium hubs, small hubs, non-hubs. Components of an airport- airside, landside. Airport as a system- function of the airport- complexity of airport operation.

**UNIT- II**

**Airport Planning:** Airport system planning, airport master plan, airport layout plan- forecasting, facilities requirements, design alternatives. Financial plans, land use planning, environmental planning.

**UNIT-III**

**Ground Handling:** Passenger handling, ramp handling- aircraft ramp servicing, ramp layout. Departure control. Division of ground handling responsibilities. Control of ground handling efficiency. Baggage handling Baggage operations-operating characteristics of baggage handling systems-inbound baggage system, outbound baggage system-operating performance-organizing for the task.

**UNIT-IV**

**Passenger Terminal Operations and Cargo Operations:** Functions of the passenger terminal, philosophies of terminal management. Direct passenger services, airline related passenger services. Airline related operational functions. Governmental requirements-non-passenger related airport authority functions, processing very important persons. Passenger information systems. Space components and adjacencies- aids to circulation-hubbing considerations.

Air cargo market- expanding the movement. Flow through the cargo terminal-unit loading devices.-Handling within the terminal-Cargo apron operation-Computerisation of facilitation-Examples of modern cargo designs-Freight operations for the integrated carrier.

**UNIT-V**



**Airport Technical Services and Access:** Scope of technical services- air traffic control- telecommunications- meteorology- aeronautical information.

Access as part of airport system- access users and modal choice, access interaction with passenger terminal operation, access modes- in-town and off-airport terminals. Factors affecting access mode choice.

**TEXT BOOK**

1. Wells, A.T. and Young, S.B., *Airport Planning and Management*, 5th edn, McGraw-Hill, 2004.

**REFERENCES**

1. Kazda, A. and Caves, R.E., *Airport Design and Operation,* 2nd edn., Elsevier, 2007.
2. *Horonjeff, R., McKelvey, F.X., Sproule, W.J. and Young, S.B., Planning and Design of Airports*, 5th edn., McGraw-Hill, 2010.
3. Ashford, N., Stanton, H. P. M. and Moore, C.A., *Airport Operations,* McGraw-Hill, 1997

**Outcome:** *The student would gain an understanding of the basic planning and operations involved in airport.*

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## (A82128) ANALYSIS OF COMPOSITE STRUCTURES

**(Elective– III)**

**Aim:** To familiarize students on the various composite materials their properties and methods for analysis.

**UNIT- I**

**Properties of Constituent Materials and Composite Laminates:** Introduction to laminated composite plates- mechanical properties of constituent materials such as matrices and filaments of different types.

Netting analysis of composite materials, determination of properties of laminates with fibers and matrices.

**UNIT- II**

**Elastic Properties:** Stress-strain relations of isotropic, orthotropic and anisotropic materials, transformation of material properties for arbitrary orientation of fibers.

**UNIT- III**

**Methods of Analysis:** Mechanics of materials approach to determine Young's modulus, shear modulus and Poisson's ratio. Brief mention of elasticity approach and macro mechanics of laminates.

Anisotropic elasticity, stress –strain relations in material coordinates - Transformation of geometric axes, strength concepts, biaxial strength theories, maximum stress and maximum strain.

**UNIT-IV**

**Analysis of Laminated Beams and Plates:** Classical plate theory, Classical lamination theory – Special cases of single layer, symmetric, antisymmetric & unsymmetric composites with cross ply, angle ply lay up. Deflection analysis of laminated plates, Analysis of laminated beams and plates.

**UNIT-V**

**Shear Deformation and Buckling Analysis:** Shear deformation theories for composite laminated beams, plates- first, second and third order theories. nth order theory.

Buckling analysis of laminated composite plates with different orientation of fibers, Tsai-wu criteria and Tsai – Hill Criteria

**TEXT BOOKS**



1. Agarwal B. D., Broutman. L. J., *Analysis and Performance of Fibre Composites*, John Wiley and sons – New York, 1980.

2. Lubin. G, *Hand Book on Advanced Plastics and Fibre Glass* , Von. Nostrand, Reinhold Co. New york, 1989.

**REFERENCES**

1. Gupta, L., *Advanced Composite Materials,* Himalayan Books, New Delhi, 1998.
2. Jones, R.M., *Mechanics of Composite Materials,* McGrawHill Kogakusha, ltd. Tokyo.
3. Reddy, J.N., *Mechanics of Composite Materials.*

**Outcome:** The students will be able to select appropriate composite materials and analyzes for different elastic properties by using various methods.

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## (A82130) HELICOPTER ENGINEERING

### (Elective-III)

**Aim:** To familiarize students on the elements of helicopter aerodynamics and ground effect machines.



**UNIT - I**

**Elements of Helicopter Aerodynamics:** Configurations based on torque reaction - Jet rotors and compound helicopters- Methods of control- Collective and cyclic pitch changes – Lead – Lag and flapping hinges.

**UNIT – II**

**Ideal Rotor Thory:** Hovering performances - Momentum and simple blade element theories - Figures of merit - Profile and induced power estimation - Constant chord and ideal twist rotors.

**UNIT - III**

**Power Estimates, Stability and Trim:** Induced, Profile and Parasite power requirements in forward flight - Performances curves with effects of altitude. Preliminary ideas on helicopter stability.

**UNIT - IV**

**Lift and Control of V/Stol Aircraft:** Various configuration - Propeller, Rotor ducted fan and jet lift - Tilt wing and vectored thrust - Performances of VTOL and STOL aircraft in hover, Transition and Forward motion.

**UNIT - V**

**Ground Effect Machines:** Types - Hover height, Lift augmentation and power calculations for plenum chamber and peripheral jet machines - Drag of hovercraft on land and water. Applications of hovercraft.

**TEXT BOOKS**

1. Johnson, W., Helicopter Theory, Princeton University Press,1980.
2. McCormick, B.W., Aerodynamics, Aeronautics & Flight Mechanics, John Wiley, 1995.
3. Gessow, A., and Myers, G.C., Aerodynamics of Helicopter, Macmillan & Co., N.Y.1987.



**REFERENCES**

1. McCormick, B.W., Aerodynamics of V/STOL Flight, Academics Press, 1987.
2. Gupta, L Helicopter Engineering, Himalayan books, 1996.

**Outcome:** The students will be able to take up design and analysis works relating to helicopter.

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## (A82131) HYPERSONIC AERODYNAMICS

### (Elective- III)

**Aim:** To familiarize the students on the various elements of hypersonic aerodynamics and their effects.

**UNIT- I**

**Introduction:** History of hypersonic flight- a logical progression in the light of advancing technical findings. Hypersonic flow- definition, importance, physical aspects. Brief descriptive introductory pre-view of various phenomena such as Thin shock layer, Entropy layer, Viscous interaction, Effects of high temperature and communication black out. Low density flow, free molecular flow.

**Hypersonic Shock and Expansion Wave Relations:** Oblique shock relations for high Mach numbers, Expansion wave relations for high Mach numbers. Theoretical basis of Mach number independence principle-corroboration by experimental results. Importance of experiments.

**UNIT- II**

**Local Surface Inclination Methods:** Newtonian flow and the hypersonic double limit of M ? ? & $\gamma$ ? 1- Modified Newtonian flow, Centrifugal force correction to Newtonian flow, Tangent wedge and tangent cone methods.

**Hypersonic Inviscid Flows- I:** Hypersonic small disturbance theory, Equivalence principle and hypersonic similarity parameter; Hypersonic shock relations in terms of similarity parameter.

**UNIT- III**

**Hypersonic Inviscid Flows- II** : Application of small disturbance theory and equivalence of 1-dimensional piston motion with 2-dimansional hypersonic flow, Flat plate at an angle of attack by piston theory and comparison with exact shock expansion method, Bi-convex airfoil at zero angle of attack: comparison of piston theory and exact shock expansion method, Phenomenological aspects of hypersonic blunt body problem, Importance of blunt body problem and brief outline of computational time-marching finite difference method and its advantage over other methods.

**UNIT- IV**



**Viscous Flows:** Derivation of compressible boundary layer equations, Brief introduction to the flat plate case and some important results and conclusions for high Mach number flows, Special characteristics of hypersonic boundary layers, Introduction to hypersonic interaction parameters – weak & strong.

**UNIT- V**

**Shock Tube Based Experimental Facilities:** Shock tunnel, Gun tunnel, Free piston wind tunnel, Ludweig tube, Measurement techniques, Samples of comparison of experimental and theoretical results.

**Other Hypersonic Facilities:** Continuous hypersonic tunnel free flight experiments in tunnels and ballistic ranges- Measurement techniques. Role of experiments in computer code validation and calibration, Brief introduction to heat transfer measurements.

**TEXT BOOKS**

1. Anderson J D, *Hypersonic and High Temperature Gas Dynamics*, 2nd Edition, AIAA Education series, 2000.
2. Bertin, J. J. , *Hypersonic Aerothermo-dynamics*, AIAA Education series, 1994.
3. Spurk, J., *Fluid Mechanics*, Springer, Heidelberg, 1997.

**REFERENCES**

1. Hayes & Probstein, *Hypersonic Flow Theory.*
2. Wendt J F, *European Hypersonic Wind Tunnels*, AGARD Conference Proceedings No. 428, Nov. 1987, Paper 2.
3. Canning T. N., Seiff A. and James, C. S., *Ballistic Range Technology*, AGARDograph Report AD 07 13915, Aug. 1970.
4. Brun, Raymond, *Introduction to Reactive Gas Dynamics*, Oxford Univ. Press, 2009, Chapter 11: Facilities and Experimental Methods.
5. Harry J Davies, H.J. and Churchack, H.D., *Shock Tube Techniques & Instrumentation*, 1969, US Army Material Command, Harry Diamond Lab, Washington DC (available on net – Free Copy).
6. Burtschell, Y., Brun, R., and Zeitoun, D., *Shock Waves*, Springer Verlag, Berlin , 1992.
7. *An Album of Supersonic Flow Visualization*, Edited by P I Kovalev & N P Mende, National Defence industry press (Write to Prof S V Bobashev, 26 politechnicheskaya street, St. Petersburg 194021, Russia).
8. Curtis, P. *Shock tubes*, Pegasus Eliot Mackenzie Publishers, October 2004.

**Outcome:** The students will be able to take up design and analysis works relating to hypersonic aerodynamics.

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### (A80331) HEAT TRANSFER

(Elective-IV)



**UNIT – I**

Introduction, Basic Modes of heat transfer – Fundamental laws of heat transfer – Simple General discussion about applications of heat transfer.

**Conduction Heat Transfer:** Fourier Heat transfer equation – General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates – simplification and forms of the field equation – steady, unsteady and periodic heat transfer – Initial and boundary conditions.

**UNIT – II**

**One Dimensional Steady State Conduction Heat Transfer:** Homogeneous slabs, hollow cylinders and spheres- Composite systems– overall heat transfer coefficient – Electrical analogy – Critical radius of insulation-Variable Thermal conductivity – systems with heat sources or Heat generation-Extended surface and fins.

**One Dimensional Transient Conduction Heat Transfer:** Systems with negligible internal resistance –Chart solutions of transient conduction systems.

**UNIT – III**

**Convective Heat Transfer:** Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow – Dimensional analysis as a tool for experimental investigation – Buckingham $\pi$ Theorem and method, application for developing semi – empirical non-dimensional correlation for convection heat transfer – Significance of non-dimensional numbers – use of empirical correlation for convective heat transfer.

**Forced convection: External Flows:** Flat plates and Horizontal pipes.

**Free Convection:** Vertical plates and pipes-concepts about Hydrodynamic and thermal boundary layer along a vertical plate.

**UNIT – IV**



**Heat Transfer With Phase Change:**

**Boiling**: – Pool boiling– Calculations on Nucleate boiling, Critical Heat flux and Film boiling.

**Condensation:** Film wise and drop wise condensation –Film Condensation on a vertical and horizontal cylinders using empirical correlations.

**Radiation Heat Transfer :** Emission characteristics and laws of black-body radiation – Irradiation – total and monochromatic quantities – laws of Planck, Wien, Kirchoff, Lambert, Stefan and Boltzmann– heat exchange between two black bodies – concepts of shape factor – Emissivity – heat exchange between grey bodies – radiation shields – electrical analogy for radiation networks.

**UNIT V**

**Heat Exchangers:** Classification of heat exchangers – overall heat transfer Coefficient and fouling factor – Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.

**TEXT BOOK :**

1. Heat& Man Transfer-D.S.Kumar/S.K.Kataria& sons.
2. Heat Transfer-P.K.Nag /Mc Graw Hill/Third Edition.

**REFERENCE BOOKS:**

1. Heat Transfer: A Practical Approach /Yunus Cengel- Boles / TMH.
2. Heat Transfer: A Conceptual Approach/PK Sharma, K. Rana Krishna/ New age International Publishers.
3. Heat Transfer / HOLMAN/TMH.
4. Heat and Mass Transfer/ R. Yadav /CPH.
5. Essential Heat Transfer/ Christopher A Long / Pearson Education.
6. Fundamentals of Engineering, Heat & Man Transfer/R.C.Sachdeva/ NewAge.

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## (A82132) LAUNCH VEHICLE AND MISSILE TECHNOLOGY

### (Elective- IV)

**Aim:** The student shall be introduced to the launch vehicle & Missile technologies.



**UNIT- I**

**Introduction:** Space launch vehicles and military missiles- function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation- similarities and differences. Materials used for launch vehicles & missiles and their selection criteria.

**UNIT-II**

**Solid & Liquid Propellant Rocket Motor Systems:** Solid propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, Liners, insulators and inhibitors- function, requirements, materials. Rocket motor casing- materials. Nozzles- types.

Liquid propellants- types, composition, properties, performance. Propellant tanks, feed systems- pressurisation, turbo-pumps- valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up.



**UNIT-III**

**Aerodynamics of Rockets And Missiles:** Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles, Rocket dispersion, re-entry body design considerations.

**UNIT-IV**

**Dynamics & Attitude Control of Rockets & Missiles:** Tsiolskovsky's rocket equation- range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn- the culmination altitude. Multi staging. Earth launch trajectories- vertical segment, the gravity turn, constant pitch trajectory, orbital injection.

Rocket thrust vector control-methods of thrust vector control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; Stage

separation dynamics, separation techniques.

**UNIT- V**

**Rocket Testing:** Ground testing and flight testing- types of tests, test facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground testing, flight testing, trajectory monitoring, post accident procedures. Description of a typical space launch vehicle launch procedure.



**TEXT BOOKS**

1. Sutton, G.P., and Biblarz, O., *Rocket Propulsion Elements*, 7th edition, Wiley-Interscience, 2000.
2. Turner, M.J.L., *Rocket and Spacecraft Propulsion*, Springer, 2001.

**REFERENCES**

1. Cornelisse, J.W., Schoyer H.F.R. and Wakker, K.F., *Rocket Propulsion and Space-flight Dynamics,* Pitman, 1979.
2. Chin, S.S., *Missile Configuration Design,* McGraw Hill, 1961.
3. Ball, K.J., Osborne, G.F., *Space Vehicle Dynamics*, Oxford University Press, 1967.
4. Parker, E.R., *Materials for Missiles and Spacecraft,* McGraw Hill, 1982.
5. Mouritz, A. and Bannister, M., *Introduction to Aerospace Materials*, CRC Press, 2010.

**Outcome:** The student shall be able to recognize various systems in launch vehicle & Missile technologies.

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**(A82133) WIND ENGINEERING AND INDUSTRIAL AERODYNAMICS**

**(ELECTIVE- IV)**



**Aim:**

The student will learn about the origin and nature of different types of Atmospheric winds from gentle breeze to destructive cyclones. He/she will gain insight into how Atmospheric wind affects civil structure, occasionally resulting in failure. He/she will also learn how Atmospheric wind is used to produce power and how Aerodynamics can be applied to improve performance of ground vehicles like cars, trucks etc.

**UNIT- I**

**Atmospheric Winds & Atmospheric Boundary Layer:** Causes of wind-thermal drive, Coriolis effect, pressure gradient effect. Geotrophic winds.

Land and sea breeze,mountain winds, thermals, cause of turbulence at ground level. Atmospheric boundary layer, velocity profile laws- effect of terrain on atmospheric boundary layer. Wind tunnels- basic features and components. Wind tunnel models- role of non-dimensional groups. Creation of atmospheric boundary layer type flow in a wind tunnel.

**UNIT– II**

**Wind Energy:** Ship propulsion- sails- lift and drag translators- modern yachts. Horizontal (HAWT) and vertical axis (VAWT) wind turbines- history, first example of automatic feedback control for yaw in 16th century English windmills, classification. Horizontal Axis Wind Turbine (HAWT —elementary actuator disc theory- Betz coefficient. Definition of Power coefficient & Torque coefficient for all wind turbines.

Working principle, power coefficients & tip speed ratio, explanation: by Introductory blade element theory — conventional Horizontal Axis Wind Turbine (HAWT), Savonious Vertical Axis Wind Turbine (VAWT) & Darrieus VAWT, Merits and demerits of HAWTs and VAWTs.

**UNIT- III**



**Vehicle Aerodynamics:** Relative importance of Rolling resistance and Aerodynamics resistance, Power requirements and drag coefficients of automobiles – notch front and notch rear windscreens versus streamlined shape, causes of vortex formation and drag— attached transverse vortex, trailing vortex, trailing vortex drag – effect of floor height on lift, effects of cut back angle, rear end taper: side panels and bottom. Effect of chamfering of edges and cambering of roof & side panels. Racing cars — ,traction, steering

grip and use of airfoils, high cornering speed. Commercial transport vehicles-drag reduction in buses, trucks; Driver cabin and trailer combinations.

**UNIT– IV**



**Building Aerodynamics:** Use of light-weight components in modern buildings, Pressure distribution on low-rise buildings, Wind forces on buildings— aerodynamics of flat plate and circular cylinder, Critical Reynolds No., Sub-, Super- & ultra-critical Reynolds No. Role of wind tunnel experiments in determining Shape Factors (Drag Coefficients) of building/ structure shapes such as circular cylinder (chimneys & towers), rectangle, D-shape, L-shape, H-shape etc. Vortex shedding & transverse oscillating loads. Slenderness ratio & correction factor. special problems of tall buildings, Interference effect of building.

**UNIT– V**

**Flow Induced Vibrations:** Classification — Vortex induced vibration & Flow induced instability such as Galloping & Stall flutter. Effects of Reynolds number on wake formation of bluff shapes. Vortex induced vibrations — Experimental determination of Strouhal numbers for different shapes such as circular cylinder, Square, rectangle, L-shape etc, Universal Strouhal No., Unsteady Bernoulli equation, Concept of added mass, Resonance, Fluid-structure interaction — effect of transverse cylinder motion on flow and wake, "Lock-in" of vortex shedding near resonant frequency. Experimental evidence of cylinder motion influencing flow and thereby reducing strength of shed vortices. Methods of suppression of vortex induced vibration.

Galloping & Stall Flutter — Motion of one degree-of-freedom, Quasi-steady flow assumption, aerodynamic damping, Galloping — force in the direction of plunging (transverse motion) and positive force coefficient,, Critical Speed, galloping of transmission wire with winter ice, Stall flutter of airfoils.

**TEXT BOOKS**

1. Blevins, R.D., Flow Induced Vibrations, Van Nostard, 1990.
2. Sachs. P., *Wind Forces in Engineering*, Pergamon Press, 1988.
3. Calvert, N.G., Wind Power Principles, Charles Griffin & Co., London, 1979.

**REFERENCES**



1. Scorer, R.S., *Environmental Aerodynamics,* Ellis Harwood Ltd, England, 1978.
2. Sovran, M., *Aerodynamics Drag Mechanisms of Bluff Bodies and Road Vehicles*, Plenum Press, N.Y., 1978.

**Outcome:** Students will be able to know different types of atmospheric winds and their effects on civil structures. Further will be able to apply to know how atmospheric wind is used to produce power and improve the performance of ground vehicle like cars, trucks etc .

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### (A82126) AEROELASTICITY
### (Elective-IV)

**Objectives:** The course starts with basic definitions of aeroelastic problems. It is assumed that students are familiar with aircraft structures, structural dynamics and steady aerodynamics; therefore only necessary basics on these subjects are provided to help to formulate different static and dynamic aeroelastic problems.



**UNIT – I**

**Introduction to Aeroelasticity :** Collar's aeroelastic triangle, interaction of aerodynamic, structural and inertial forces, static aeroelasticity phenomena, dynamic aeroelasticity phenomena, aeroelastic problems at transonic speeds, aeroelastic tailoring, active flutter suppression.

**UNIT - II**

**Structural Dynamic and Unsteady Aerodynamic Aspects:** Generalized coordinates and generalized forces, Strain energy, kinetic energy and dissipation function, Lagrange's equations of motion, Formulations of structural dynamics equation, Hamilton's principle, and orthogonality conditions.

Small perturbation theory, Two-dimensional unsteady flow over wings, simple harmonic motion, Theodorsen's function, arbitrary motion and Wagner function, gust problem, Küssner function.

**UNIT - III**

**Static Aeroelastic Problems:** Static aeroelastic studies using strip theory - divergence, control effectiveness and control reversal; slender straight wing and swept wings, Static aeroelastic problems of low aspect ratio wings.

**UNIT - IV**

**Dynamic Aeroelastic Phenomenon – Flutter** Formulation of aeroelastic equations for a typical section, Torsion-flexure flutter – solution of flutter determinant, Method of determining the classical flutter speed using Theodorsen's and U-g methods, Modal aeroelastic equations including lifting surface theory, flutter analysis using k- and p-k methods, Flutter prevention and control,



**UNIT - V**

**Dynamic Aeroelastic Response** Gust and turbulence, Gust response in time domain – heave motion of rigid aircraft, heaving-pitching motion of rigid aircraft, flexible aircraft; General form of equations in the time domain,

Turbulence response in the frequency domain - rigid aircraft in heave, rigid aircraft in heave/pitch, flexible aircraft, General form of equations in the frequency domain, Representation of the flight control system (FCS).

**TEXT BOOKS**


1. Wright, J.R., and Cooper, J.E., Introduction to Aircraft Aeroelasticity and Loads, John Wiley and Sons Ltd, 2007.
2. Bisplinghoff, R. L., Ashley, H. and Halfman, R. L., *Aeroelasticity,* Addison-Wesley Publishing Company, Cambridge, Mass., 1955., Dover Pub., Inc., 1996, (BAH).
3. Fung, Y.C., An Introduction to the Theory of Aeroelasticity, Dover Publication, Inc., 1969.
4. Scanlan, R.H., and Rosenbaum, R., Introduction to the Study of Aircraft Vibration and Flutter, The MacMillan Co., 1962.
5. Dowell, E.H., (Editor), et al, A Modern Course in Aeroelasticity, Fourth Revised and Enlarged Edition, Kluwer Academic Publishers, 2004. (Advanced text).


**REFERENCES**


1. F?rsching, H.W., Grundlagen der Aeroelastik, Springer-Verlag, 1974. (Excellent book, written in German but easy to understand).
2. Bisplinghoff, R. L., and Ashley, H., *Principles of Aeroelasticity,* John Wiley and Sons, Inc., New York, N.Y., 1962. Also available in Dover Edition. (BA).
3. AGARD Manual on Aeroelasticity, Vols. I-VII, Beginning 1959 with continual updating. (AGARD).
4. Broadbent, E.G., *The Elementary Theory of Aeroelasticity,* Aircraft Engineering, 1954.
5. Abramson, H.N., An Introduction to the Dynamics of Airplanes, Ronald Press Co., 1958 (reprinted by Dover).


**Outcome:** At the end of this course students will be in a position to solve aeroelastic divergence, control effectiveness, control reversal, flutter and aeroelastic response problems using strip theory aerodynamics.

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**(A80087) INDUSTRY ORIENTED MINI PROJECT**

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