COURSE CONTENTS

OF

B. TECH. & MINOR PROGRAMS

IN

AEROSPACE ENGINEERING,
IIT BOMBAY

FOR

BATCHES OF 2022 AND ONWARDS

(Updated 24th July, 2023)

I. Core Theory Courses

Title of the course	**AE 103 A Historical Perspective of Aerospace Engineering**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	PART-I: • The scientific revolution of the 17th century -- mechanics of the craftsmen and mathematics of the scholars are fused to explain the universe. • The 18th century enlightenment movement and growing dominance of the scientific worldview. • The 19th century steam engine and electric generator, and the industrial revolution. Evolutionary perspectives in geology, biology and society. The professionalization of science and development of its secular and elite character. • The 20th century - the birth of new physics and chemistry of the atomic and subatomic world, and related technologies. The birth of computing machines, aerodynamic and space technologies. The growing knowledge of cellular and molecular biology, and human diseases. • The 21st century - the global concerns for public health and pandemics, ecological devastation and agricultural crisis, social and economic inequality, remain and continue to grow. PART-II: 1. History of Aerospace Engineering a. Aeronautics and Aerospace – Aircrafts and Rockets b. Basic structure/geometry/terminology of aircrafts and rockets c. Basic science of flight – Number of disciplines involved in aerospace technology d. Stories of flight – Across the world e. Evolution in flying – balloons and gliders f. Flight of heavier than air object – First flight, First rockets 2. Major milestones (discoveries and inventions) and its impact on society and industrial revolution, including negative impacts on the society. a. Global milestones – First balloon flight, powered flight, V2 rockets, Supersonic flight, civilian supersonic, Shuttle flights, SPACEX etc. b. Indian milestones – First Indigenous aircraft design- HF24, LCA, ALH, SLV, PSLV, GSLV etc. 3. Evolution of ethics and practices in the discipline – Nuclear and Chemical Weapons control, Export control laws etc. 4. Important persons, their biographies, struggle, and success – Indian and global 5. Voices from the field (invited talks from practitioners and professionals) – Have couple of talks every semester 6. Recent and cutting edge research in the discipline 7. Prospective directions of evolution of the discipline in the near future.
Texts/References	1. Silver, B. L., The Ascent of Science, Oxford University Press, 2000 2. Bronowski, J., The Ascent of Man, Random House, 2011 3. Mayr, E., This is Biology: The Science of the Living World, Harvard University Press, 1997 4. Kelley, F. C., The Wright Brothers: A Biography, George G. Harrap & Co, 1994 5. Rajkumar, P., Tejas Story: The Light Combat Aircraft Project, Manohar Publishers and Distributors, 2007

	6. Anderson, Jr., J. D., The Grand Designers: The Evolution of the Airplane in the 20th Century, Cambridge University Press, 2018

Title of the course	**AE 152 Introduction to Aerospace Engineering**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	Historical Developments in Aviation, Aviation milestones, Components of an aircraft, Types of aerial vehicles. Basic Aerodynamics: Fluid dynamic equations & their basis, Ideal fluid, viscous flows, Flow past a body, Flow Separation, Generation of Lift, Drag & Moment, Non-dimensional coefficients, Airfoils & Wings, Airfoil families, Supersonic flight, Wave Drag, Aircraft Drag Polar, Properties of atmosphere: ISA, IRA, Pressure altitude, Altimeter; Aircraft speeds TAS, EAS, CAS, IAS. Types of Powerplant for aerospace vehicles, Thrust/Power and fuel flow variation with altitude & velocity. Aircraft Performance: Steady level flight, Altitude effects, Absolute ceiling, steady climbing flight, Energy methods, Range and Endurance, Sustained level turn, pull-up, Take-off and Landing.
Texts/References	1. Anderson, Jr., J. D., The Aeroplane, a History of its Technology, AIAA Education Series, 2002 2. Anderson, Jr., J. D., Introduction to Flight, McGraw-Hill Professional, 2005 3. Ojha S.K., Flight Performance of Aircraft, AIAA Education Series, 1995

Title of the course	**AE 223 Thermodynamics and Propulsion**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	Basic concepts: System boundary, surroundings, state, extensive and intensive properties, energy interactions, work and heat transfers, equilibrium, quasi-static and reversible processes, non-equilibrium and irreversible processes. Thermodynamic laws: Zeroth law and temperature, first law and internal energy, first law applied to flow processes, second law, entropy and absolute temperature, third law and absolute entropy, thermodynamics of simple compressible systems, energy and energy. Applications: Closed and open systems, polytropic processes, cyclic processes, Carnot cycle; Cycle analysis: Otto cycle, Diesel cycle, Joule-Brayton cycle; ideal and real cycles. Basic principles of heat transfer: conduction, convection and radiation. Introduction to aero-engine cycles: ramjets, turbojets, turbofans and turboprops/turboshafts, ideal and real cycles, component performance.
Texts/References	1. Sonntag, R. E., Borgnakke ,C. and Van Wylen , G. J., Fundamentals of Thermodynamics, 6th ed., Wiley, 2002 2. Cengel, Y., and Boles, M., Thermodynamics: an Engineering Approach, 7th ed., McGraw Hill, 2010 3. Nag, P. K., Engineering Thermodynamics, 4th ed., Tata McGraw Hill, 2008 4. Rogers and Mayhew, Engineering Thermodynamics: Work and Heat Transfer, 4th Ed, Longman Scientific, 1992. 5. Cengel, Y., and Ghajar, 4 Edition, McGraw Hill, Heat transfer: A practical approach, McGraw Hill, 2nd ed., 2002 6. Hill, P., and Peterson, C., Mechanics and Thermodynamics of Propulsion, Pearson Education, 2009

	7. Farokhi, Saeed, Aircraft Propulsion, Wiley-Blackwell 2nd ed., 2014.

Title of the course	**AE 227 Solid Mechanics**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	Introduction: Engineering Statics v/s Solid Mechanics, solid as a continuum, statement of a general solid mechanics problem. Elements of 2-D & 3-D Elasticity: components of stress & strain fields, stress/strain transformation, principal stresses, plane stress/strain, Mohr's circle, equilibrium equations, strain displacement relations, compatibility conditions, natural & kinematic boundary conditions, stress-strain relations, generalized Hooke's Law - Isotropy, Orthotropy, Anisotropy. Displacement and force methods of analysis. Concepts of linear and nonlinear problems. Illustration of linear elasticity solutions - problems in 2-D (rectangular and polar co-ordinates), stress function approach. St. Venant's principle. Material behaviour: introduction to metallic and non-metallic materials of aerospace interest, awareness/overview of structure of materials. Ductile, brittle, elasto-plastic and viscoelastic material behaviour - Elastic and strength properties. Composite materials. Materials selection. Failure of engineering materials, failure theories, concepts of fatigue, fracture and creep. 1-D structural analysis: slender structural elements, assumptions simplifying the general (3-d) stress, strain and deformation fields for uncoupled axial deformation, uncoupled bending, and uncoupled twisting of slender 1-D elements and development elementary beam theory, idealization of general loads into axial forces, bending moments, shear forces and torque distributions, deflection and stress analysis of rods, beams and circular shafts. Introduction to energy methods – strain energy, virtual work, minimum potential energy. Introduction to energy principles and its applications. Introduction to Truss analysis. Riveted joints. Measurement of strain and displacement. Measurement of elastic and strength properties. ASTM standards.
Texts/References	1. Gere, J. M., ``Mechanics of Materials", Thomson, 6th ed. 2007. 2. Crandall, S.H., Dahl, N.C. and Lardner, T.J. ``An Introduction to the Mechanics of Materials", McGraw-Hill, International Edition, 1978. 3. Timoshenko, S.P. and Goodier, J.N. ``Theory of Elasticity", McGraw-Hill, International Edition, 1970.

Title of the course	**AE 238 Aerospace Structural Mechanics**
Credit Structure	3-0-0-6
Prerequisite	AE 227 Solid Mechanics
Course Content	Introduction: semi-monocoque aerospace structures - Loads and Design considerations; construction concepts, layout, nomenclature and structural function of parts, strength v/s stiffness based design. Torsion of non-circular prismatic beams: importance of warping; St. Venant or Prandtl's formulation; Membrane analogy and its application to narrow rectangular cross-section. General formulation of Thin-Walled Beam (TWB) Theory: Cartesian and midline systems, CSRD & thin-wall assumptions, general expressions for dominant

	displacement, strain and stress fields, equilibrium equations in midline system, stress resultants and general boundary conditions. Torsion and Bending of TWBs: Torsion of single and multi cell closed sections - Bredt-Batho theory, shear flow, torsion constant, free warping calculation, and concept of center of twist, torsional equilibrium equation and boundary conditions. Torsion of open TWBs without warp restraint, primary & secondary warping, St. Venant torsion constant. Uncoupled bending of open, closed, single cell, multi-cell TWBs - axial stress, shear flow, shear centre, displacement analysis. Torsion of open section TWBs with primary warp restraint - concept and theory of torsion bending, torsion bending constant, secondary warping restraint. Unsymmetric bending and coupled bending torsion analysis. Buckling of TWBs: Concept of structural instability, flexural buckling analysis, bending of beams under combined axial and lateral loads, short column and inelastic buckling. Pure torsional buckling and coupled flexural-torsional buckling of open TWBs. Introduction to the concept of buckling of plates, local buckling of TWBs. Introduction to buckling and post-buckling of stiffened skin panels, ultimate load carrying capacity of a typical semi-monocoque TW box-section. Introduction to tension-field beams.
Texts/References	1. Megson, T. H. G., Aircraft Structures for Engineering Students, Butterworth-Heinemann, 4th ed., 2007. 2. Peery, D. J., Aircraft Structures, McGraw-Hill Education, 1st ed., 1950. 3. Donaldson, B. K., Analysis of Aircraft Structures (Cambridge Aerospace Series), 2nd ed., Cambridge University Press, 2008. 4. Sun, C. T., Mechanics of Aircraft Structures, Wiley-Interscience, 1998. 5. Bruhn, E. F., Analysis and Design of Flight Vehicle Structures, Jacobs Pub., 1973. 6. Niu, M., Airframe Stress Analysis & Sizing, Adaso Adastra Engineering Center, 1998. 7. Cutler, J. and Liber, J., Understanding Aircraft Structures, Wiley Blackwell, 4th ed., 2006.

Title of the course	**AE 244 Low Speed Aerodynamics**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	• Introduction • Review of streamline, pathline, and streakline, dilatation, strain rate • Circulation and vorticity • Conservation of mass, momentum and energy in fixed, deforming, and moving control volumes • Kinematics of fluid flows, Lagrangian and Eulerian descriptions • Equation of motion in differential form • Bernoulli's equation • Similitude, dimensional analysis, and modeling; important non-dimensional groups in fluid mechanics • Potential flow: stream function and velocity potential, source, sink, doublet, vortex and their superpositions • Kutta-Joukowski theorem • Thin airfoil theory • Panel methods • Potential flow over lifting wing: lifting line theory, vortex lattice method • Viscous flow, exact solutions, pipe flow • Laminar boundary layers

Texts/References	1. White, F. M., Fluid Mechanics (SI Units), 7th ed., McGraw Hill, 2011 2. Panton, R. L., Incompressible Flow, 3rd ed., Wiley India Edition, 2006 3. Cengel, Y. A., Cimbala, J. M., Fluid Mechanics (Fundamentals and Applications), 2nd ed., Tata McGraw Hill, 2010 4. Anderson, Jr., J. D., Fundamentals of Aerodynamics, 6th ed., McGraw Hill, 2017 5. Bertin, J. J. and Cummings, R. M., Aerodynamics for Engineers, 6th ed., Pearson, 2013 6. Houghton, E. L., Carpenter, P. W., Collicott, S. H. and Valentine, D. T., Aerodynamics for Engineers, 6th ed., Butterworth-Heinemann, 2013

Title of the course	**AE 308 Control Theory**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	Introduction: Control situations & control objectives, broad control tasks, open-loop and closed-loop control concept, various types of control structures, unity negative feedback control systems, basic control actions. Two-position Control Systems: On-off control concept and action of an ideal relay, 1st and 2nd order system on-off control, effect of hysteresis on the closed-loop control performance, relay modelling. System response: Response of higher order systems to standard and generic inputs in Laplace and time domains, concept of partial fractions. System Stability: Concept of system stability and connection with its response, asymptotic and bounded-input bounded-output stability, role of characteristic roots in stability, Routh's criterion for absolute and relative stability analysis, including unknown parameter-based stability. Proportional Control Systems: Proportional control action modelling, stability and response of proportional control systems, concept of root locus and its application to proportional control system analysis. Frequency Response: Concept of frequency domain and frequency response, response representation using bode, Nyquist and Nichol's plots, closed-loop system analysis using frequency response attributes, Nyquist stability analysis. Closed-loop Response Attributes: Transient and steady-state response concept, tracking control task and closed-loop error constants, integral control option for tracking, transient response and role of derivative action. Closed-loop Response Control Elements: PI controllers and lag compensators for tracking control tasks, PD controllers and lead compensators for transient response control tasks, PID controllers and lag-lead compensators for complex control tasks. Design of Closed-loop Control Systems: Closed-loop performance specifications, gain and phase margins as design specifications, use of root locus, Bode plots, Nyquist plots and Nichol's plots in closed-loop control design, design rules, methodologies and guidelines for different types of control tasks.
Texts/References	1. Ogata, K., Modern Control Engineering, 5th ed., Prentice Hall India, 2010 2. Kuo, B. C. and Golnaraghi, F., Automatic Control Systems, 8th ed., John Wiley & Sons, 2003 3. D`Azzo, J. J. and Houpis, C. H., Linear Control Systems Analysis and Design – Conventional and Modern, 4th ed., McGraw-Hill, 1995 4. Nise, N. S., Control Systems Engineering, 3rd ed., John Wiley & Sons, 2001 5. Franklin, G. F., Powell, J. D. and Emami-Naeini, A., Feedback Control of Dynamic Systems, 5th ed., Pearson Prentice Hall, LPE, 2006 6. Gopal, M., Control Systems – Principles and Design, 3rd ed., Tata McGraw-Hill, 2008

Title of the course	**AE 332 Aircraft Design**
Credit Structure	3-0-0-6
Prerequisite	AE 152 Introduction to Aerospace Engineering
Course Content	Introduction to Aircraft Design: Three phases in aircraft design, Computer based aircraft design methodologies, differences between LTA and HTA aircraft, type of civil and military aircraft. Configuration and Layout: Types and comparison of wing, tail, fuselage, landing gear, wing-tail combinations, power plant (types, numbers, locations), unconventional aircraft configurations. Sizing and Constraint Analysis: Initial sizing, estimation of design gross weight, rubber engine sizing and fixed engine sizing, refined sizing method and constraint analysis. Estimation Methodologies: Lift and drag coefficient, design loads, component mass breakdown, acquisition cost, direct operating cost. Operational and Environmental Issues: Range-payload diagram, V-n diagram, noise and emission levels.
Texts/References	1. Raymer, D. P., Aircraft Design - A Conceptual Approach, AIAA Educational Series, 4th ed., 2006. 2. Brandt, S. A., Stiles, R. J., Bertin, J. J., Whitford, R., Introduction to Aeronautics: A Design Perspective, AIAA Educational Series, 2nd ed., 2004. 3. Jenkinson, L. R., Simpkin, P. and Rhodes, D., Civil Jet Aircraft Design, Arnold Publishers, London, 1999. 4. Fielding, J., Introduction to Aircraft Design, Cambridge Aerospace Series, Cambridge University Press, 1999. 5. Kundu, A.K, Aircraft Design, Cambridge Aerospace Series, Cambridge University Press, ISBN-13 978-0-521-88516-4, 2010.

Title of the course	**AE 339 High Speed Aerodynamics**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	Introduction: Conservation laws, equivalence of momentum and energy equations, isentropic flow, speed of sound, Mach waves, static and stagnation conditions Subsonic compressible flow past airfoils: Linearized velocity potential equation, Prandtl-Glauert compressibility corrections, critical Mach number, drag divergence Mach number, effect of sweep, supercritical airfoils, area rule Supersonic flows: Stationary and moving normal shock waves, Pitot probes in compressible flows, oblique shocks, shock interactions, shock reflection from boundaries, shockwave-boundary layer interaction, Prandtl-Meyer expansion fans, interaction of expansion waves, reflection of expansion waves from boundaries, shock-expansion wave interaction, unsteady expansion waves superpositions; Transonic flow: Transonic flow past unswept airfoils, transonic similarity rules, numerical methods in transonic flows, supersonic flow past airfoils, linearized supersonic flow, shock expansion method, supersonic flow over wings, subsonic/supersonic leading edge. Internal aerodynamics: Mach Number and area relationship, critical conditions, convergent nozzles, convergent-divergent nozzles, under- and over-expanded nozzle flows, convergent-divergent supersonic diffusers, supersonic wind tunnels, shock tubes

	Hypersonic flows: Introduction to hypersonic flows, real gas effects, Newtonian theory, lift and drag in hypersonic flows, hypersonic shockwave relations, Mach number independence
Texts/References	1. Anderson, Jr., J. D., Modern Compressible Flow: with Historical Perspective, 3rd ed., McGraw Hill, 2003. 2. Oosthuizen, P. H. and Carscallen, W. E., Compressible Fluid Flow, 2nd ed., CRC Press, 2013. 3. Yahya, S. M., Fundamentals of Compressible Flow, 3rd ed., New Age International, New Delhi, 2003 4. Anderson, Jr., J. D., Fundamentals of Aerodynamics, 6th ed., McGraw Hill, 2017 5. Bertin, J. J. and Cummings, R. M., Aerodynamics for Engineers, 6th ed., Pearson, 2013 6. Houghton, E. L., Carpenter, P. W., Collicott, S. H. and Valentine, D. T., Aerodynamics for Engineers, 6th ed., Butterworth-Heinemann, 2013

Title of the course	**AE 341 Flight Mechanics of Aircrafts and Spacecrafts**
Credit Structure	3-0-0-6
Prerequisite	Exposure to AE 103 and AE 152 is recommended
Course Content	The course is aimed at providing an introduction to the mechanics of rigid aircrafts and spacecrafts. It includes a selection of topics on static and dynamic aircraft flight stability and orbital mechanics. • Essential features of aircraft and spacecraft operations and flight • Basics of static equilibrium and stability of aircrafts (longitudinal, lateral, and roll) • A concise introduction to dynamics of rigid bodies (inertia, parameterization of rotation) • Elements of aircraft flight dynamics, including stability derivatives and maneuvers • Spacecraft attitude dynamics • Orbits in two dimensions • Orbits in three dimensions • Orbital maneuvers
Texts/References	1. Curtis, H., Orbital Mechanics for Engineering Students, 4th ed., Butterworth-Heinemann, 2019 2. Bate, R. R., Mueller, D. D., White, J. E. and Saylor, W. W., Fundamentals of Astrodynamics, 2nd ed., Dover Publications, 2020 3. Thomson, W. T., Introduction to Space Dynamics, Dover Publication, 1986 4. Perkins, C. D. and Hage, R. E., Airplane Performance, Stability, and Control, John Wiley & Sons, 1949 5. Nelson, R., Flight Stability and Automatic Control, 2nd ed., McGraw Hill, 2017 6. Sinha, N. K. and Ananthkrishnan, N., Elementary Flight Dynamics with an Introduction to Bifurcation and Continuation Methods, CRC Press, 2021

Title of the course	**AE 344 Aero Propulsion**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	• Introduction to various aircraft propulsive devices: piston-prop, turbo-prop, turbojet, turbofan, turboshaft, vectored-thrust, lift engines. • Gas turbine cycles and cycle-based performance analysis; 1-D and 2-D analysis of flow through gas turbine components – intake, compressors, turbines, combustion chamber, afterburner, and nozzle.

	• Other propulsion systems: ramjets, scramjets and pulsejets • Introduction to various rocket engine concepts: thrust equation, rocket performance parameters, mission analysis, and multi-staging • Nozzle theory, combustion of propellants, thrust vectoring. • Rocket vehicles: Solid propellant rockets, liquid propellant rockets, electric thrusters: concepts, constructional features, propellants
Texts/References	1. Cumpsty, N. and Heyes, A., Jet Propulsion, 3rd ed., Cambridge University Press, ISBN: 978-1107511224 2. Ramamurthi, K., Rocket Propulsion, 1st ed., Laxmi Publications, ISBN: 978-9385750007 3. Heister, S., Anderson, W. E., Pourpoint, T. L. and Cassady, R. J., Rocket Propulsion, 1st ed., Cambridge University Press, ISBN: 978-1108422277 4. Farokhi, S., Aircraft Propulsion, 3rd ed., Wiley, ISBN: 978-1119718642 5. Hill, P. and Peterson, C., Mechanics and Thermodynamics of Propulsion, 2nd ed., Pearson, ISBN: 978-8131729519

II. Laboratory Courses

Title of the course	**AE 229 Introduction to Aerodynamics and Propulsion Laboratory**
Credit Structure	0-0-3-3
Prerequisite	Nil
Course Content	Force (drag) measurement using load balance, flow visualization in water tunnel, Rubin's tube for combustion visualization, Pitot static probe and manometer for velocity measurement
Texts/References	Laboratory Manuals of Aerospace Engineering Department

Title of the course	**AE 231 Introduction to Aerospace Structures and Control Laboratory**
Credit Structure	0-0-3-3
Prerequisite	Nil
Course Content	Four experiments focused on demonstrating typical tests used to determine material characterization and structural response, strain measurement, and exposure to aircraft's behavior. These experiments are as follows: • Testing of aerospace materials under axial loading, demonstration of ductile and brittle behavior of materials, and the determination of material elastic properties and strength • Testing of aerospace structures under flexural loading, bending tests to determine structural deflection, and material Young's modulus • Application of Wheatstone bridge for strain measurement, derivation of strain and resistance variations, and application of strain gauge measurement • Introduction to flight simulation, trimming of aircraft for various operating points
Texts/References	1. Anderson, Jr., J. D., Introduction to Flight, McGraw-Hill Professional, 2005 2. Doebelin, E. and Manik, D., Doebelin's Measurement Systems, 6th ed., McGraw-Hill Education 3. Laboratory Manual, Aircraft Structures Lab., Dept. of Aerospace Engineering, IIT Bombay, 2023

Title of the course	**AE 233 Control Systems Laboratory**
Credit Structure	0-0-3-3
Prerequisite	AE 308 (Control Theory) or equivalent
Course Content	• Modeling and identification of plant dynamics for different types of systems • Reinforcement of basic control concepts: Proportional, integral, and derivative feedback applied to simple control systems such as servo control, temperature control, and gyroscope. • Real system effects: Effect of friction, backlash, resistance, loading, and transport lag on the control system behavior. • Frequency response: Experimental generation, application to closed loop system stability analysis. • Lab Project: Design of a control system involving simulation studies, hardware implementation, and demonstration.
Texts/References	1. Ogata, K., 'Modern Control Engineering', 5th ed., Prentice Hall India, Eastern Economy Edition, 2010. 2. User Manuals of the various experimental setups

Title of the course	**AE 246 Aircraft Structures Laboratory**
Credit Structure	0-0-3-3
Prerequisite	Nil
Course Content	The experiments in this laboratory course cover the following: • Fabrication of fiber reinforced composite laminate. • Tension, compression, interlaminar shear, impact and hardness testing for determination of elastic moduli and strength of material. • Coefficient of thermal expansion. • Strain measurement. • Inverse methods for material property determination (Poisson's ratio and Young's Modulus) using measured static and dynamic structural response in conjunction with simple structural models. • Shear center of open section thin-walled beam, displacement and strain distribution in bending and torsion of twin-walled open and closed section beams. • Buckling of beams/plates. • Measurement of natural frequency, natural modes and modal damping of beams.
Texts/References	Laboratory Manual, Aircraft Structures Lab., Dept. of Aerospace Engineering, IIT Bombay, 2007.

Title of the course	**AE 343 Aerodynamics Laboratory**
Credit Structure	0-0-3-3
Prerequisite	Nil
Course Content	• Types of low-speed wind tunnels and their characteristics, suction and blowdown tunnels, closed and open jet tunnels • Pitot probes and velocity measurement • Characteristics of a planar jet flow, self-similarity • Boundary layer flow over a flat plate, estimation of displacement and momentum thicknesses and shape factor, locating laminar, transitional and turbulent boundary layers • Flow past airfoil and measurement of pressure drag, estimation of drag by wake survey method, measurement of unsteady flow using hot-wire anemometer • Shock tube measurements, incident and reflected shock waves.
Texts/References	1. Goldstein, R. J., Fluid Mechanics Measurements, Taylor and Francis, 1996 2. Pope A., and Goin, K. W., High Speed Wind Tunnel Testing, John Wiley & Sons, 1985 3. Barlow, J. B., Rae, W. H., Pope, A., Low-Speed Wind Tunnel Testing, 3rd ed., Wiley-Interscience, 1999

Title of the course	**AE 345 Aircraft Propulsion Laboratory**
Credit Structure	0-0-3-3
Prerequisite	Nil
Course Content	• Study of gas turbine cycle and engine operation characteristics • Flow through nozzle – pressure distribution and thrust measurement • Characteristics of impulse and reaction turbine • Measurement of laminar flame speed • Fuel injection system

Texts/References	1. Hill, P., and Peterson, C., Mechanics and Thermodynamics of Propulsion, Pearson Education, 2009. 2. Laboratory Manual, Propulsion Laboratory, Department of Aerospace Engineering, IIT Bombay, 2007.

Title of the course	**AE 429 Aircraft Design Project**
Credit Structure	1-0-4-6
Prerequisite	Exposure to AE 332
Course Content	Students complete a group project involving conceptual design of an aircraft, while meeting some stated requirements. The group project is aimed to achieve the following learning goals for the students: • To provide hands-on experience related to Aircraft Design • To be able to plan and execute a multi-disciplinary design task • To be able to successfully present the results of the design task verbally and in the form of a report and drawings • To learn to work efficiently in a group and as a member of the group.
Texts/References	1. Raymer, D. R., User Manual for RDS-Professional, Software for Aircraft Design, Analysis & Optimization, Version 5.2, Conceptual Research Corporation, California, USA 2007 2. Roskam, J., User Manual for Advanced Aircraft Analysis (AAA) Software, Version 3.1, Design, Analysis and Research Corporation, Kansas, USA, 2006

III. Minor Theory Courses (Core)

Title of the course	**AE 153 Introduction to Aerospace Engineering**
Credit Structure	3-0-0-6
Prerequisite	Nil
Course Content	Historical Developments in Aviation, Aviation milestones, Components of an aircraft, Types of aerial vehicles. Basic Aerodynamics: Fluid dynamic equations & their basis, Ideal fluid, viscous flows, Flow past a body, Flow Separation, Generation of Lift, Drag & Moment, Non-dimensional coefficients, Airfoils & Wings, Aerofoil families, Supersonic flight, Wave Drag, Aircraft Drag Polar, Properties of atmosphere: ISA, IRA, Pressure altitude, Altimeter; Aircraft speeds TAS, EAS, CAS, IAS. Types of Powerplant for aerospace vehicles, Thrust/Power and fuel flow variation with altitude & velocity. Aircraft Performance: Steady level flight, Altitude effects, Absolute ceiling, steady climbing flight, Energy methods, Range and Endurance, Sustained level turn, pull-up, Take-off and Landing.
Texts/References	1. Anderson, Jr., J. D., The Aeroplane, a History of its Technology, AIAA Education Series, 2002 2. Anderson, Jr., J. D., Introduction to Flight, McGraw-Hill Professional, 2005 3. Ojha S.K., Flight Performance of Aircraft, AIAA Education Series, 1995

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