COURSE CONTENTS
B. Tech., Dual Degree, Honors & Minor Programmes in Aerospace Engineering, IIT Bombay
(Last Update on 29th July, 2021)

I. Core Theory Courses

1.	Title of the course	**AE 102 Data Analysis and Interpretation**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	Course Content	The role of statistics. Graphical and numerical methods for describing and summarising data. Probability. Population distributions. Sampling variability and sampling distributions. Estimation using a single sample. Hypothesis testing a single sample. Comparing two populations or treatments. Simple linear regression and correlation. Case studies.
5.	Texts/References	1. Sheldon M. Ross, Introduction to Probability and Statistics for Engineers and Scientist, Academic Press, 2005.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 152 Introduction to Aerospace Engineering**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	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.
5.	Texts/References	1. Anderson, J. D., The Aeroplane, a History of its Technology, AIAA Education Series, 2002 2. Anderson, J. D., Introduction to Flight, McGraw-Hill Professional, 2005 3. Ojha S.K., Flight Performance of Aircraft, AIAA Education Series, 1995
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 223 Thermodynamics and Propulsion**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	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.
5.	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.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 225 Incompressible Fluid Mechanics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	Course Content	Introduction. Fluid properties, fluid forces, and flow regimes. Fluid statics. Kinematics of fluid flows, Lagrangian and Eulerian descriptions. Streamline, Pathline, and Streakline, Dilatation strain rate, Circulation, Vorticity. Local and global decomposition of fluid flows. Conservation of mass, momentum and energy in fixed, deforming, and moving control volumes. Bernoulli's equation. Potential Flow, Stream Function and Velocity potential, Source, Sink, Doublet, Vortex. Similitude, dimensional analysis, and modelling; Important non-dimensional groups in fluid mechanics. Equation of motion in differential form. Viscous flow, exact solutions, pipe flow. Laminar boundary layers. Boundary layer solution methods. Introduction to Turbulence, Reynolds averaging, Reynolds stress, Mixing length model. Turbulent boundary layer.
5.	Texts/References	1. White, F. M., Fluid Mechanics (SI Units), 7th Ed., Special Indian Edition, 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.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 227 Solid Mechanics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	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.
5.	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.
6.	Other depts. to whom the course is relevant	

1.	Title of the course	**AE 234 Aircraft Propulsion**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 223 Thermodynamics and Propulsion
4.	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. Compressor and Turbine blade shapes; cascade theory; radial equilibrium theory; matching of compressor and turbine. Turbine cooling. Single spool and Multi- spool engines. Powerplant performance with varying speed and altitude. Other propulsion systems: ramjets, scramjets and pulsejets.
5.	Texts/References	1. Saravanamuttoo, H.I.H, Rogers, G. F. C., Cohen, H., Gas Turbine Theory, ISBN 978-0130158475, 5th Ed, Prentice Hall, 2001 2. Hill, P., and Peterson, C., Mechanics and Thermodynamics of Propulsion, ISBN 978-0132465489, Pearson Education, 2009. 3. Mattingly, J. D., Elements of Gas Turbine Propulsion, Tata McGraw Hill Edition, 2005 4. El-Sayed, A., Aircraft Propulsion and Gas Turbine Engines, ISBN 978-0849391965, 1st Ed., CRC Press, 2008 5. Roy, B., Aircraft Propulsion: Science of Making Thrust to Fly, 1st Ed., Elsevier India, 2011
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 236 Compressible Fluid Mechanics**
2.	Credit Structure	3-0-0-6
3	Prerequisite	AE 225 Incompressible Fluid Mechanics
4.	Course Content	Review of Fundamentals. Concept of Waves in fluid, Mach waves, Compression waves, Expansion waves. Isentropic flow, Adiabatic flow, Shock waves. Stationary and Moving Normal Shocks. Oblique Shocks, Bow Shocks in 2D. Conical Shocks, Bow Shocks in 3D. Shock interactions, Shock reflection from boundaries, Shockwave Boundary Layer interaction. Prandtl-Meyer expansion fans. Shock Expansion Methods. Mach Number and Area rule, Flow through a Nozzle: Convergent Nozzle, Convergent Divergent Nozzle, Under-expanded and Over-expanded Nozzle flows. Duct flow with friction and heat addition. Shock Tubes. Supersonic and Transonic Wind tunnels. Potential flow equations. High temperature aspects of gas dynamics. Introduction to hypersonic flows.
5.	Texts/References	1. Anderson, J. D., Modern Compressible Flow: with Historical Perspective, 3rd Ed., McGraw Hill, 2003. 2. Yahya, S.M., Fundamentals of Compressible Flow, 3rd Ed., New Age International, New Delhi, 2003
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 238 Aerospace Structural Mechanics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 227 Solid Mechanics
4.	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.
5.	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.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 240 Spaceflight Mechanics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	Course Content	Introduction: Space missions and role of launch vehicles and spacecraft, Historical Perspective. Ascent Mission: Ascent mission objectives, mathematical models governing ascent mission, rectilinear and gravity turn ascent trajectories, effect of aerodynamic drag and gravity on ascent mission performance. Multi-stage Launch Vehicles: Concept of multi-staging, staging solution sensitivity analysis, series and parallel staging configurations, optimal staging solutions. Launch Vehicle Attitude Motion: Short period attitude motion models, nature of attitude response to atmospheric disturbances. Basic Orbital Solution: Two-body Problem solution, Kepler`s laws & equation, classical orbital elements, orbit determination from initial conditions, position and velocity prediction from orbital elements, different types of orbits, perturbation due to earth oblateness and solar radiation pressure, non-Keplerian formulation and restricted 3-body problem, sphere of activity & Roche' limit. Satellite Operations: Orbit raising manoeuvre, Hohmann and low thrust transfer manoeuvres, orbit inclination change maneuver, orbit perigee change manoeuvre, launch to orbit and docking manoeuvres, launch window concept. Spacecraft Motion: Interplanetary motion basics, departure and arrival solutions, planetary transfers, gravity assist trajectories. Descent Mission: Orbit decay solution, concept of re-entry mission, ballistic and other reentry mechanisms. Spacecraft Attitude Motion: Torque-free motion models, effect of energy dissipation on stability of rotational motion, overview of actuation mechanisms for attitude control.
5.	Texts/References	1. Cornelisse, J.W., Schoyer, H.F.R. and Wakker, K.F., 'Rocket Propulsion and Spaceflight Dynamics', Pitman, London, 1979. 2. Thompson, W. T., 'Introduction to Space Dynamics', Dover Publications, New York, 1986. 3. Pisacane, V.L. and Moore, R.C., 'Fundamentals of Space Systems', Oxford University Press, 1994. 4. Wiesel, W. E., 'Spaceflight Dynamics', 2nd Ed., McGraw-Hill, 1997. 5. Wie, B., 'Space Vehicle Dynamics and Control', AIAA Education Series, 1998. 6. Meyers, R.X., 'Elements of Space Technology for Aerospace Engineers', Academic Press, 1999.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 305 Flight Mechanics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 152 Introduction to Aerospace Engineering
4.	Course Content	Introduction: Equilibrium, static stability, control. Longitudinal stability and control: Longitudinal equilibrium and static stability, stick fixed neutral point, all moving horizontal tail OR elevator as longitudinal control. Trimmed lift curve slope and advantages of reduced/negative longitudinal static stability. Hinge moments, reversible control, stick force, and trim tab. Stick free static stability, stick-free neutral point. Lateral-directional stability and control: Directional equilibrium, stability and rudder as control. Lateral stability, dihedral angle, aileron control. Dynamical equations: Euler angles. Body angular velocity and Euler angle rates. Body-fixed axis, wind axis, stability axes. Equations of motion of rigid aircraft in body fixed axes. Stability derivatives. Steady flight and perturbed flight leading to linearized equations of motion. Aircraft motion modes: Decoupling of longitudinal dynamics and lateral-directional dynamics. Short period and phugoid modes of longitudinal dynamics. Dutch roll, spiral and roll subsidence modes of lateral-directional dynamics. Effect of winds. Flight simulation.
5.	Texts/References	1. Stengel, R. F., Flight Dynamics, Princeton University Press, 2004. 2. Roskam, J., Airplane Flight Dynamics and Automatic Flight Controls, DAR Corporation, 1995. 3. Nelson, R. C., Flight Stability and Automatic Control, Mc Graw Hill International, 1990. 4. Etkin, B. and Duffy, L. D., Dynamics of Flight: stability and control, John Wiley, NY 1995.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 308 Control Theory**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	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.
5.	Texts/References	1. Ogata, K., 'Modern Control Engineering', 5th Ed., Prentice Hall India, Eastern Economy Edition, 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., David Powell, J. &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.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 326 Vibrations and Structural Dynamics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 227 Solid Mechanics
4.	Course Content	Single degree of freedom system vibrations, Free and Forced Undamped and Damped Vibrations. Periodic and General Excitations: Duhamel Integral Approach. Introduction to Vibration Isolation. Discrete systems with multiple degrees of freedom, elastic and inertia coupling, Natural frequencies and modes, free vibration response, Orthogonality of natural modes, modal analysis, Forced vibration response, special and general cases of damping, matrix formulations, solution of the Eigen Value problem. Vibration of continuous systems, differential equations and boundary conditions, Free and forced longitudinal, flexural and torsional vibrations of one-dimensional structures, Elements of analytical dynamics, generalized coordinates, Principle of Virtual Work, Hamilton Principle, Lagrange equations, Applications. Modal analysis. Approximate methods based on Lagrange equation and assumed modes. Structural damping.
5.	Texts/References	1. Meirovitch, L., Elements of Vibration Analysis, 3rd Ed. McGraw-Hill Book Co., 2001. 2. Weaver, W., Timoshenko, S. P. and Young, D. H., Vibration Problems in Engineering, 5th Ed. John-Wiley and Sons, 1990. 3. Clough, R.W. and Penzien, J., Dynamics of Structures, 2nd Ed. McGraw-Hill, 1993.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 330 Aerospace Propulsion**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 223 Thermodynamics and Propulsion and AE 236 Compressible Fluid Mechanics
4.	Course Content	Introduction, Various propulsive devices used for aerospace applications. Classifications of rockets: Electric, Nuclear and Chemical rockets, Applications of rockets. Nozzle design: Flow through nozzle, Real nozzle, Equilibrium and frozen flow, Adaptive and non-adaptive nozzles. Thrust vector controls, Rocket performance parameters. Solid propellant rockets, Grain compositions. Design of grain. Liquid propellant rockets, Injector design, cooling systems, Feed Systems: Pressure feed and turbo-pump feed system. Heat transfer problems in rocket engines.
5.	Texts/References	1. Sutton, G. P., and Biblarz, O., Rocket Propulsion Elements, 7th Ed., Wiley India Pvt. Ltd., 2010. 2. Oates, G. C., Aerothermodynamics of Gas Turbine and Rocket Propulsion, AIAA, 1988 3. Barrere, M., Jaumotte, A., de Veubeke, B. F., Vendenkerchove, J., Rocket Propulsion, Elsevier Publishing Company, Amsterdam, 1960. 4. Mukunda H. S. Understanding Aerospace Chemical Propulsion, Interline Publishing, Bangalore, 2004
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 332 Aircraft Design**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 152 Introduction to Aerospace Engineering
4.	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.
5.	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.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 333 Aerodynamics**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	AE 152 Introduction to Aerospace Engineering AE 225 Incompressible Fluid Mechanics
4.	Course Content	Airfoils, wings and their nomenclature; lift, drag and pitching moment coefficients; centre of pressure and aerodynamic centre. Potential flow Analysis; Scalar and vector fields, velocity potential, line, surface and volume integrals, circulation and lift generation, Kutta-Joukowski theorem. Method of superposition, thin airfoil theory, source and vortex methods. Subsonic compressible flow past airfoils; Critical Mach number, drag divergence Mach number, supercritical airfoils, effect of sweep, area rule. Full and perturbation velocity potential formulations; Prandtl-Glauert compressibility corrections. Transonic flow past airfoils, transonic similarity rules; Supersonic flow past airfoils, linearized supersonic flow, shock expansion method. Potential flow over lifting wing; lifting line theory, vortex lattice method, slender body theory, panel method, variation of lift and drag coefficients in subsonic flows with angle of attack, Reynolds number, thickness-to-chord ratio. Supersonic flow over airfoils and wings; subsonic/supersonic leading edge. Hypersonic flows, real gas effects, Newtonian theory, lift and drag in hypersonic flows.
5.	Texts/References	1. Anderson, J. D., Jr., Fundamentals of Aerodynamics, McGraw Hill 2001. 2. Bertin, J. J., Aerodynamics for Engineers, Pearson Education, 2002. 3. Houghton, E. L. and Carpenter, P. W., Aerodynamics for Engineers, Butterworth-Heinemann, 2001.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 407 Modelling and Simulation**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	Course Content	Introduction: Simulation classification, Objectives, concepts and types of models. Modelling: 6-DOF models for aerospace vehicle with prescribed control surface inputs. Control systems – Mechanical (structural), hydraulic and their modelling. Block diagram representation of systems. Dynamics of aerospace vehicles: Pilot station inputs, Cues for the pilot – Visual, biological and stick force. Virtual simulation. Fly-by-Wire system simulation. Uncertainty Modelling& Simulation: Characterization of uncertainty in model parameters and inputs, use of simulation to propagate the uncertainty to system response, Monte-Carlo simulation. Simulation of stiff systems – differential algebraic equations. Applications: Modelling and simulation methodologies for a complex engineering system simulation, aerospace system simulation. Model Building Techniques: Parameter identification, system identification. Least Square Estimation, Maximum likelihood estimation. Modelling and simulation of thermal systems. Discrete system modelling and simulation.
5.	Texts/References	1. Ogata, K., 'System Dynamics', 4th Ed. Pearson Education LPE, 2004. 2. Doebelin, E. O., 'System Dynamics: modelling, analysis, simulation, designs', New York: Marcel Dekker, 1998. 3. Ljung, L., 'System Identification - Theory for the User', Prentice Hall, 1987. 4. Stevens, B.L. and Lewis, F.L., 'Aircraft Control and Simulation', John Wiley and Sons, 1992. 5. Blakelok, J.H., 'Automatic Control of Aircraft and Missiles', Wiley-Interscience, 1991. 6. Vladislav, Klein and Eugene A.M., 'Aircraft System Identification Theory and Practice', AIAA education series, 2006.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 410 Navigation and Guidance**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	Course Content	Fundamentals of Navigation, Stellar Navigation, Inertial Navigation, Radio and Radar based Navigation Systems, Global Positioning System, Other Specialized Navigation Systems, A Comparison of the various Navigational Aids, Some Case Studies. Fundamentals of Guidance, Concepts of Intercept Geometry, Line of Sight and Collision Triangle, Proportional Navigation & Guidance (PNG) and Determination of Miss Distance, Augmented PNG and its comparison with PNG, Command to LOS & Beam Rider Guidance, Pulsed and Lambert`s Guidance, Tactical Vs. Strategic Considerations in Guidance, Impact of Noise on Guidance, Target maneuver and Evasion.
5.	Texts/References	1. Anderson, E.W., 'The Principles of Navigation', Hollis & Carter, London, 1966. 2. Kayton, M., 'Navigation : Land, Sea, Air, Space', IEEE Press, 1990. 3. Parkinson, B.E. & Spilker, J. J., 'Global Positioning System: Theory and Applications', Vol.1, Progress In Aeronautics and Astronautics Series, Vol.163, AIAA Publication, 1996. 4. Zarchan, P., 'Tactical & Strategic Missile Guidance', AIAA Education Series, 2nd Ed., AIAA Publication, 1992. 5. Biezad, D.J., 'Integrated Navigation and Guidance Systems', AIAA Education Series, 1999. 6. Farrell, J.L, 'Integrated Aircraft Navigation', Academic Press, 1976. 7. Misra, P. and Enge, P., 'Global Positioning System', 2nd Ed., Ganga-Jamuna Press, 2001.
6.	Name of other Departments to whom the course is relevant	

II. Laboratory Courses

1.	Title of the course	**AE 242 Aerospace Measurements Laboratory**
2.	Credit Structure	2-0-2-6
3.	Prerequisite	Nil
4.	Course Content	Characteristics of measuring systems: Calibration, sensitivity and error analysis. Air data measurements: Pressure altitude, airspeed Flow measurements: Hotwire anemometer, manometer, angle of attack sensor Temperature Measurements: Thermocouples, hot gas and cryogenic measurements, thermopiles Strain measurements: Strain gage types, strain gage sensitivity. Pressure measurements: Dependence of measurement dynamics on sensor construction. Inertial and GPS based sensors: Accelerometers and gyroscopes; position, velocity and time measurements. Attitude and heading reference systems: Errors in inertial sensors and characterization. Sensor interfacing: amplifiers, filters, and other signal conditioning circuits, analog and digital conditioning, ADC/DAC, synchronous and asynchronous serial communication.
5.	Texts/References	1. Doeblin, E., Measurement Systems: Application and Design, 4th Ed., McGraw-Hill, New York, 1990. 2. Grewal, M. S., Lawrence, R. and Andrews, A., GPS, INS and Integration, New York: John Wiley, 2001. 3. Collinson, R. P. G., Introduction to Avionics, Chapman and Hall, 1996. 4. Gayakwad, R. A., OPAMPs and Linear Integrated Circuits, 4th Ed., 4th Ed., Pearson Education, 2005. 5. Titterton, D. H. and Weston, J. L., Strapdown Inertial Navigation Technology, 2nd Ed., AIAA Progress in Astronautics and Aeronautics, Vol. 207, 2004. 6. Strang, G. and Borr, K., Linear Algebra, Geodesy and GPS, Wellesley-Cambridge Press, 1997. 7. Doebelin, Ernest O. and Manik, Dhanesh N., Doebelin's Measurement System, 6th Edition, New Delhi: Tata McGraw-Hill, 2011 8. Setup User Manuals and Component Data Sheets.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 312 Aerodynamics Laboratory**
2.	Credit Structure	1-0-3-5
3.	Prerequisite	AE 225 Incompressible Fluid Mechanics, AE 236 Compressible Fluid Mechanics AE 333 Aerodynamics
4.	Course Content	Types of wind tunnels and their characteristics, wind tunnel corrections Flow past bluff and a streamlined bodies and measurement of pressure drag. Wall shear flows, free shear flows, development of boundary layer on flat plate with and without pressure gradient, free shear layer in a jet, estimation of drag by wake survey method. Flow in a variable area duct and experimental determination of mass flow coefficient. Flow visualization methods, surface flow methods and color die injection method. Measurement of unsteady flow using hot-wire and Laser Doppler Velocimeter
5.	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., ISBN 978-0471557746, Wiley-Interscience, 1999.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 314 Aircraft Structures Laboratory**
2.	Credit Structure	1-0-3-5
3.	Prerequisite	AE 227 Solid Mechanics AE 238 Aerospace Structural Mechanics
4.	Course Content	The aerospace structures laboratory includes experiments related to material aspects as well as structural mechanics. These experiments are largely based upon the syllabus covered in the courses on AE 227 Solid Mechanics and AE 238 Aerospace Structural Mechanics. A couple of experiments on vibrations and structural dynamics are also included for exposure. The experiments in this laboratory course cover the following: Fabrication of fibre 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 centre 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.
5.	Texts/References	Laboratory Manual, Aircraft Structures Lab., Dept. of Aerospace Engineering, IIT Bombay, 2007.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 316 Aircraft Propulsion Laboratory**
2.	Credit Structure	1-0-3-5
3.	Prerequisite	AE 234 Aircraft Propulsion AE 225 Incompressible Fluid Mechanics
4.	Course Content	Study of aircraft engine models, basic measurement techniques inthermal, mechanical and fluid systems. Experimentation related to aerodynamics and performance of turbomachinery (in axial flow fan set-up and in two-dimensionalcompressor/turbine cascades), fuel systems, combustion and heattransfer (convective heat transfer to geometries typical of aerospacepropulsion applications) in aerospace propulsion systems. Experiments on performance characteristics of gas turbine/jetpropulsion systems.
5.	Texts/References	1. Hill, P., and Peterson, C., Mechanics and Thermodynamics of Propulsion, ISBN 978-0132465489, Pearson Education, 2009. 2. Laboratory Manual, Propulsion Laboratory, Department of Aerospace Engineering, IIT Bombay, 2007.
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 427 Control Systems Laboratory**
2.	Credit Structure	1-0-3-5
3.	Prerequisite	AE 308 Control Theory
4.	Course Content	Reinforcement of basic control concepts: Proportional, integral and velocity feedback applied to simple control systems such as servo control, temperature control, gyroscope, and flexible shafts. 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.
5.	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
6.	Name of other Departments to whom the course is relevant	

1.	Title of the course	**AE 429 Aircraft Design Project**
2.	Credit Structure	1-0-4-6
3.	Prerequisite	AE 332 Aircraft Design
4.	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: 1. To provide hands-on experience related to Aircraft Design, 2. To be able to plan and execute a multi-disciplinary design task, 3. To be able to successfully present the results of the design task verbally and in the form of a report and drawings, 4.To learn to work efficiently in a group and as a member of the group.
5.	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, August 2006.
6.	Name of other Departments to whom the course is relevant	

III. Minor Theory Courses (Core)

1.	Title of the course	**AE 153 Introduction to Aerospace Engineering**
2.	Credit Structure	3-0-0-6
3.	Prerequisite	Nil
4.	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.
5.	Texts/References	1. Anderson, J. D., The Aeroplane, a History of its Technology, AIAA Education Series, 2002 2. Anderson, J. D., Introduction to Flight, McGraw-Hill Professional, 2005 3. Ojha S.K., Flight Performance of Aircraft, AIAA Education Series, 1995
6.	Name of other Departments to whom the course is relevant	

Document History

2021-07-29: Created