SCHEME AE 2017-18.pdf

UTD_3-8 sem syllabus_AERO 2017.18 .pdf

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Department of Mechanical Engineering

Scheme &Syllabus

of

Bachelor of Technology

Aeronautical Engineering

From III to VIII Semester

Effective from Academic session 18-19
For students admitted in session 2017-18

University Teaching Departments

Rajasthan Technical University, Kota

Scheme of B. Tech. Aeronautical Engineering, 3rd Semester

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
3ANU1	Mechanics of Solids	50	100	150	3	1	0	4	3
3ANU2	Fluid Mechanics	50	100	150	3	0	0	3	3
3ANU3	Introduction to Aeronautics	50	100	150	3	0	0	3	3
3ANU4	Aircraft Materials Engineering	50	100	150	3	0	0	3	3
3ANU5	Manufacturing Processes	50	100	150	3	0	0	3	3
3ANU6	Advanced Engineering Mathematics-1	50	100	150	3	1	0	4	3
3ANU7	Introduction to Aeronautics Lab	50	25	75	0	0	3	3	2
3ANU8	Fluid Mechanics Lab	50	25	75	0	0	3	3	2
3ANU9	Mechanics of Solids Lab	35	15	50	0	0	2	2	1
3ANU10	Aircraft Materials Lab	35	15	50	0	0	2	2	1
3ANU11	Professional Skill Lab	35	15	50	0	0	2	2	1
3ANUDC	Discipline & Extra Curricular activity			50	0	0	0	0	1
	Sub Total			**1250**	**18**	**2**	**12**	**32**	**26**

Scheme of B. Tech. Aeronautical Engineering, 4th Semester

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
4ANU1	Aerodynamics – I	50	100	150	3	1	0	4	3
4ANU2	Engineering Thermodynamics	50	100	150	3	0	0	3	3
4ANU3	Aircraft Structure – I	50	100	150	3	0	0	3	3
4ANU4	Theory of Machine	50	100	150	3	0	0	3	3
4ANU5	Machine Design	50	100	150	3	0	0	3	3
4ANU6	Advanced Engineering Mathematics – II	50	100	150	3	1	0	4	3
4ANU7	Aerodynamics – I Lab	50	25	75	0	0	3	3	2
4ANU8	Manufacturing Technology Lab	50	25	75	0	0	3	3	2
4ANU9	Aircraft Structure – I Lab	35	15	50	0	0	2	2	1
4ANU10	Object Oriented Programming Lab	35	15	50	0	0	2	2	1
4ANU11	Contemporary Challenges/Business Communication Skills	35	15	50	0	0	2	2	1
4ANUDC	Discipline & Extra Curricular activity			50	0	0	0	0	1
	Sub Total			**1250**	**18**	**2**	**12**	**32**	**26**

As already Uploaded For 2017-18 on website

Scheme of B. Tech. Aeronautical Engineering, 5th Semester

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
5ANU1	Aerodynamics – II	50	100	150	3	1	0	4	3
5ANU2	Aircraft Performance	50	100	150	3	1	0	4	3
5ANU3	Heat Transfer	50	100	150	3	0	0	3	3
5ANU4	Elements of Vibration	50	100	150	3	0	0	3	3
5ANU5	Aircraft Systems	50	100	150	3	0	0	3	3
5ANU6.1	Rotorcraft Dynamics	50	100	150	3	0	0	3	3
5ANU6.2	Smart Materials								
5ANU6.3	Automobile Engineering								
5ANU6.4	Introduction to Robotics								
5ANU7	CAD Lab	45	30	75	0	0	3	3	2
5ANU8	Heat Transfer Lab	45	30	75	0	0	3	3	2
5ANU9	Element of Vibration Lab	35	15	50	0	0	2	2	1
5ANU10	Aircraft System Lab	35	15	50	0	0	2	2	1
5ANU11	Professional ethics & disaster management	35	15	50	0	0	2	2	1
5ANUDC	Discipline & Extra Curricular activity			50	0	0	0	0	1
	Sub- Total			**1250**	**18**	**2**	**12**	**32**	**26**

The already approved and uploaded scheme for 2017-18 will be applicable as per the discussion with BOS members.

(B. TRIPATHI) (M. Shadwal) (A. Khandelwal) (SS Gedam)

Scheme and Syllabus of B. Tech. Aeronautical Engineering, 5th Semester for 2017-18 admitted

(Anand Bansal)

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Scheme of B. Tech. Aeronautical Engineering, 6th Semester

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
6ANU1	Aerospace Propulsion– I	50	100	150	3	1	0	4	3
6ANU2	Aircraft Structure– II	50	100	150	3	1	0	4	3
6ANU3	Aircraft Stability and Control	50	100	150	3	0	0	3	3
6ANU4	Space Dynamics	50	100	150	3	0	0	3	3
6ANU5	Mechanics of Composites	50	100	150	3	0	0	3	3
6ANU6	Elective –II	50	100	150	3	0	0	3	3
6ANU6.1	Unmanned Aerial Vehicles								
6ANU6.2	Experimental Fluid Mechanics								
6ANU6.3	ME Elective								
6ANU6.4	Fatigue and Fracture								
	.								
6ANU7	Aircraft Propulsion Lab	50	25	75	0	0	3	3	2
6ANU8	Aeromodelling Design and Fabrication lab	50	25	75	0	0	3	3	2
6ANU9	Advanced Programming in MATLAB	35	15	50	0	0	2	2	1
6ANU10	Mechatronics Lab	35	15	50	0	0	2	2	1
6ANU11	Business Communication Lab	35	15	50	0	0	2	2	1
6ANUDC	Discipline & Extra Curricular Activity			50	0	0	0	0	1
	Sub- Total			**1250**	**18**	**2**	**12**	**32**	**26**

Scheme of B. Tech. Aeronautical Engineering, 7th Semester

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
7ANU1	Aerospace Propulsion– II	50	100	150	3	1	0	4	3
7ANU2	Aircraft Design	50	100	150	3	1	0	4	3
7ANU3	Introduction to Computational Fluid Dynamics	50	100	150	3	0	0	3	3
7ANU4	Finite Element Methods	50	100	150	3	0	0	3	3
7ANU5	Automatic Control Systems	50	100	150	3	0	0	3	3
7ANU6	Elective –III	50	100	150	3	0	0	3	3
7ANU6.1	Non-Destructive Testing								
7ANU6.2	Artificial Intelligence								
7ANU6.3	Experimental Stress Analysis								
7ANU6.4	Fuel Cells and Hybrid Engine Technologies								
7ANU7	CFD Lab	50	25	75	0	0	3	3	2
7ANU8	Aircraft Design lab	50	25	75	0	0	3	3	2
7ANU9	FEM Lab	35	15	50	0	0	2	2	1
7ANU10	Minor Project	0	50	50	0	0	2	2	1
7ANU11	Practical Training	35	15	50	0	0	2	2	1
7ANUDC	Discipline & Extra Curricular Activity			50	0	0	0	0	1
	Sub- Total			**1250**	**18**	**2**	**12**	**32**	**26**

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Scheme of B. Tech. Aeronautical Engineering, 8th Semester (w.e.f. 2017-18 admitted)

OPTION – A

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
8ANU1	Avionics	50	100	150	3	0	0	3	3
8ANU2	Refrigeration and Air-Conditioning	50	100	150	3	0	0	3	3
8ANU3	Airport Management and Aircraft Maintenance	50	100	150	3	0	0	3	3
8ANU4	Elective – IV	50	100	150	3	0	0	3	3
8ANU4.1	Missile Technology								
8ANU4.2	Viscous Flow								
8ANU4.3	Fundamental of Combustion								
8ANU4.4	Operation Research								
8ANU5	Avionics Lab	50	25	75	0	0	3	3	2
8ANU6	Refrigeration and Air-Conditioning Lab	50	25	75	0	0	3	3	2
8ANU7	Flight Simulation Lab	50	25	75	0	0	3	3	2
8ANU8	Seminar	75	50	125	0	0	3	2	2
8ANU9	Major Project	150	100	250	0	0	10	10	5
8ANUDC	Discipline & Extra-Curricular Activities			50	0	0	0	0	1
	Sub-Total			**1250**	**12**	**0**	**22**	**34**	**26**

OPTION – B

Codes	Scheme	Internal	External	Max Marks	Contact hours/week				Credits
					L	T	P	Total	
8ANE1	Internship	400	750	1150	0	0	48	48	24
8ANE2	Seminar	25	75	100	0	0	3	3	2
	Sub-Total			**1250**			**51**	**51**	**26**

(B. Tripathi) (M. Shahid) (S. S. Ghosh) (Anil K. Mathur)

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Syllabus of B. Tech. Aeronautical Engineering, 3rd Semester

Codes	Syllabus
3ANU1	**Mechanics of Solids**
	Introduction: Concept of stress, axial loading normal stress, shearing stress, bearing stress, stress on an oblique plane under axial loading; Concept of strain, normal strain under axial loading; Stress-strain diagrams; Hooke's law for 2D and 3D cases; Modulus of elasticity, Poisson's ratio, bulk modulus, modulus of rigidity, shearing strain; Thermal stresses. **Transformation of Stress and Strain:** Principal stresses, maximum shearing stress; Mohr's circle for stress and strain; Stresses in thick and thin-walled pressure vessels. **Stresses in Beams:** Shear force and bending moment diagrams for simply supported and cantilever beams with concentrated, uniformly distributed and variable loads; Theory of pure bending; Bending stress variation in cross-section; Transverse shear stress and its distribution in different sections; Composite beam. **Deflection of Beams:** Deflection in simply supported beams and cantilever with concentrated loads, uniformly distributed loads and their combination. **Columns:** Buckling of columns, differential equation approach, energy approach, approximate techniques; Euler's formula for pin-ended columns and its extension to columns with other end conditions; Concept of equivalent length; Eccentric loading; Rankine formula and other empirical relations. **Torsion:** Deformation in a circular shaft, angle of twist; Stresses due to torsion; Torsion in composite shafts; Saint-Venant's theorem. TEXT BOOKS:- 1. "An Introduction to the Mechanics of Solids", S.H. Crandall, N.C. Dahl, T.J. Lardner & M.S. Sivakumar, McGraw-Hill 2. "Fundamentals of Solid Mechanics: A Treatise on Strength of Materials", M.L. Gambhir, PHI Learning REFERENCE BOOKS:-

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	1. "Mechanics of Materials", S.P. Timoshenko & J.M. Gere, CBS Publishers 2. "Mechanics of Materials", Beer, Johnston, Dewolf & Mazurek, Tata McGraw Hill 3. "Strength of Materials", Sadhu Singh, Khanna Publishers 4. "Mechanics of Materials", R.C. Hibbeler, Pearson 5. "Mechanics of Solids", T.J. Lardner & R.R. Archer, McGraw-Hill College
3ANU2	**Fluid Mechanics**
	Fluid Properties: Concept of fluid and flow, ideal and real fluids, continuum concept; Pressure, density, specific gravity, viscosity, compressibility, specific heats, capillarity and surface tension; Newtonian and non-Newtonian fluids. **Fluid Statics**: Pascal's law; Hydrostatic equation; Principle of barometer and manometer; Buoyancy. **Fluid Kinematics**: Eulerian and Lagrangian description of fluid flow; System and control volume concept; Stream, streak and path line, equation of streamline, different types of flows; Conservation of mass in a control volume; Differential equation of continuity; Acceleration, rotation and strain rate of a fluid particle. **Fluid Dynamics**: Linear and angular momentum conservation equation in integral form; Euler's equation; Bernoulli's equation; Conservation of energy; Flow measuring devices – orificemeter, venturimeter, pitot tube. **Viscous Flow**: Navier-Stokes equation, unidirectional flow between stationary and moving parallel plates, flow through pipes, Hagen-Poiseuille law; Reynolds number and its significance. **Introduction to Turbulent Flows**: Reynolds experiment, laminar to turbulent transition; Reynolds decomposition; Shear stress in turbulent flow, eddy viscosity; Prandtl's mixing length hypothesis. **Boundary Layer**: Boundary layer concept; Displacement, momentum and energy thickness; Laminar and turbulent boundary layer flows; Boundary layer separation and control, streamlined and bluff bodies, lift and drag on cylinder and airfoil. **Dimensional Analysis**: Fundamental and derived units and dimensions; Dimensional homogeneity; Dimensional analysis using Rayleigh method & Buckingham-Π theorem; Significance of dimensionless group, use of dimensionless groups in experimental

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	investigation; Geometric, kinematic and dynamic similarity, model testing; Derivations and applications of important dimensionless numbers. TEXT BOOKS:- 1. "Fluid Mechanics", F.M. White, McGraw Hill Publishing Company Ltd. 2. "Fluid Mechanics: Fundamentals and Applications", Y.A. Cengel & J.M. Cimbala, McGraw Hill Education REFERENCE BOOKS:- 1. "Mechanics of Fluids", I.H. Shames, McGraw Hill Publishing Company Ltd. 2. "Fluid Mechanics", P.K. Kundu and I.M. Cohen, Academic Press 3. "Fluid Mechanics", J. F. Douglas, Pearson education 4. "Introduction to Fluid Mechanics", J.A. Fay, MIT Press 5. "Introduction to Fluid Dynamics", R.W. Fox, A.T. McDonald, P.J. Pritchand, McGraw Hill
3ANU3	**Introduction to Aeronautics**
	History of Aviation: Brief history of flight vehicle development with emphasis on key ideas, Indian aerospace activities; Aerospace applications. **Aircraft Configurations:** Classification of aircraft and space vehicles; Functions of major components of airplane; Different types of flight vehicles; V/STOL configurations; Basic flight instruments. **Standard Atmosphere:** Physical properties and structure of atmosphere; Geometric and geopotential altitude; Hydrostatic equation; Definition of standard atmosphere; Pressure, density & temperature altitudes. **Basic Aerodynamics:** Introduction to principle of flight; Ideal fluid, viscous flows, laminar and turbulent flows; Flow past a body, bluff bodies versus streamlined body, concept of boundary layer, flow separation, generation of lift, drag & moment, types of drag, non-dimensional coefficients; Airfoil, airfoil geometry, flow over airfoil, centre of pressure and aerodynamic centre, airfoil families; Wings, wing planform and orientation, flow over finite wing; Propagation of sound, different flight regimes, critical and drag divergence Mach number, wave drag, swept wing, delta wing.

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	Aerospace Structures: Basic function of aircraft structure; Aircraft configuration and principle types of construction; Details of constructional features of conventional aircraft; Use of metallic, non-metallic and composite materials; Introduction to landing gears. **Aerospace Propulsion:** Fundamental gas turbine cycle and propulsion techniques; Mechanism of thrust production in propellers and jet engines, comparative merits; Different types of aircraft engines; Principles of operation of rocket, rocket engine, typical applications, Jet Assisted Take-Off. **Basic Flight Mechanics:** Forces and moments on airplane; Significance of L/D ratio; Aircraft Drag Polar; High lift devices; Equation of motion; Thrust and power required for steady level flight; Thrust and power available and maximum velocity for jet engine and reciprocating engine-propeller combination; Climbing flight, Absolute and service ceilings; Gliding flight; Turning flight; Concepts of stability & control; Primary and secondary control surfaces; Criteria for longitudinal static stability, neutral point; Lateral-directional stability and control; Basic manoeuvres. TEXT BOOKS:- 1. "Introduction to Flight", J.D. Anderson, McGraw Hill Education 2. "Understanding Flight", D. Anderson & S. Eberhardt, McGraw Hill Education REFERENCE BOOKS:- 1. "Flight without Formulae", A.C. Kermode, Pearson Education 2. "Fundamentals of Flight", Richard Shepherd Shevell, Pearson Education 3. "The Airplane: A History of its Technology", J.D. Anderson, AIAA 4. "Flight: The Complete History of Aviation", R.G. Grant, DK Publishing 5. "Introduction to Aerospace Engineering with a Flight Test Perspective", Stephen Corda, Wiley-Blackwell
3ANU4	**Aircraft Materials Engineering**
	Atomic Structure of Metals: Crystal structure; Crystal lattice of BCC, FCC & HCP, crystallographic notation of atomic planes and directions (Miller Indices); Polymorphism and allotropy; Imperfections in crystals.

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	Theories of Plastic Deformation: Phenomenon of slip, twinning, recovery, recrystallization and grain growth; Iron carbon equilibrium diagram, phase transformation in the iron carbon diagram, formation of austenite, transformation of austenite into pearlite, martensite transformation in steel; TTT curves. **Heat Treatment Processes of Engineering Materials:** Principles and applications of annealing, normalizing, hardening, and tempering; Chemical heat treatment of steels − carburizing, nitriding, cyaniding, carbo-nitriding of steel. **Broad Classification of Engineering Materials:** Ferrous materials, nonferrous materials and alloys; Classification of steels, BIS standards; Ceramic materials; Fibre reinforced composite materials and polymers; Maraging steels and super alloys; Effects of alloying element on the structure and properties of steel, distribution of alloying elements (Si, Mn, Ni, Cr, Mo, Co, W, Ti, Al) in steel. **Materials in Aircraft Construction**s: Aluminium, titanium, copper, magnesium based alloys, steels; Composite materials. **Corrosion**: Detection and prevention; Protective coatings. **Testing:** Destructive and non-destructive testing techniques; Crack detection; Inspection of parts by hot oil and chalk, dye-penetrant, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods. TEXT BOOKS:- 1. "Aircraft Materials and Processes", G.F. Titterton, Himalayan Books 2. "Materials Science and Engineering", W.D. Callister Jr., D.G. Rethwisch, John Wiley & Sons REFERENCE BOOKS:- 1. "Aircraft Materials and Analysis", Tariq Siddiqui, McGraw-Hill 2. "Aircraft Materials & Processes", Dorothy Kent, Shroff Publication 3. "Materials Science and Engineering: A First Course", V. Raghavan, PHI Learning Private Limited 4. "Material Science and Engineering", W.F. Smith, J. Hashemi & R. Prakash, McGraw Hill Education 5. "Materials for Engineering", W. Bolton, Newnes
3ANU5	**Manufacturing Processes**

	Introduction: Importance of manufacturing, survey of manufacturing processes. **Foundry:** Casting process; Patterns— types, materials and allowances; Types of moulds; Core & core prints; Gating system; Introduction to special casting methods; Casting defects. **Metal Joining Processes:** Principle of welding, soldering, brazing and adhesive bonding; Arc welding, TIG, MIG; Gas welding and cutting; Thermite welding; Resistance welding; Spot, projection & seam welding; Atomic hydrogen, ultrasonic, plasma, laser & electron beam welding; Friction and explosive welding; Welding defects. **Forming and Shaping Processes:** Metal working, elastic and plastic deformation, concept of strain hardening, hot and cold working; Rolling principle and operations; Forging, hammers and presses; Extrusion, wire and tube drawing processes; Cold working processes— shearing, drawing, squeezing, blanking, piercing, deep drawing, coining & embossing, riveting, thread rolling, bending; Metal working defects. **Powder Metallurgy:** Methods of powder manufacturing; Properties of metal powders; Compacting; Sintering; Applications of powder manufacturing, advantages and limitations of powder manufacturing. **Rapid Prototyping Operations:** Additive & subtractive processes; Introduction to different additive manufacturing processes; Virtual Prototyping. **Plastic Technology:** General properties of plastics, classification of plastics; Ingredients of moulding compounds; Introduction to different plastic part manufacturing processes. TEXT BOOKS:- 1. "Manufacturing Technology", P.N. Rao, Tata McGraw Hill 2. "Manufacturing Processes for Engineering Materials", S. Kalpakjian & S.R. Schmid, Pearson Education REFERENCE BOOKS:- 1. "Manufacturing Science", A. Ghosh & A.K. Mallik, Pearson India 2. "Introduction to Manufacturing Processes", John A. Schey, McGraw-Hill Education 3. "Elements of Manufacturing Processes", B.S. Nagendra Parashar & R.K. Mittal, PHI Learning Private Limited

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	4. "Manufacturing Processes", J.P. Kaushish, Prentice Hall India Learning Private Limited 5. "A Textbook of Production Technology", P.C. Sharma, S. Chand
3ANU6	**Advanced Engineering Mathematics – I**
	Laplace Transform: Definition and existence of Laplace transform, properties and formulae; Unit step function, Dirac Delta function, Heaviside function; Inverse Laplace transform; Convolution theorem; Application of Laplace transform to ordinary differential equations. **Fourier Transform:** Fourier complex, sine and cosine transform, properties and formulae; Inverse Fourier transforms, Convolution theorem; Application of Fourier transforms to partial differential equations. **Z-Transform:** Definition, properties and formulae; Convolution theorem; Inverse Z-transform, application of Z-transform to difference equation. **Numerical Analysis:** Interpolation; Difference operators: forward, backward, central, shift and average operators; Newton's forward and backward interpolation formulae; Gauss's forward and backward interpolation formulae; Stirling's formula; Lagrange interpolation formula for unequal intervals; Inverse interpolation. **Numerical differentiation:** Newton's, Gauss's and Stirling's formula. **Numerical integration:** Trapezoidal Rule; Simpson's 1/3 and 3/8 rule. **Numerical solution of ODEs of first order:** Picard's method; Euler's method; Modified Euler's method; Runge-Kutta fourth order method; Milne's method. TEXT BOOKS:- 1. "Advanced Engineering Mathematics", R.K. Jain & S.R.K. Iyengar, Narosa Publications 2. "Advanced Engineering Mathematics", O'Neil, Cengage Learning India REFERENCE BOOKS:- 1. "Advanced Engineering Mathematics", E. Kreyszig, Wiley

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	2. "Advanced Engineering Mathematics", M. Greenberg, Pearson Education 3. "Advanced Engineering Mathematics", D.G. Zill & W.S. Wright, Jones & Bartlett India Private Limited 4. "Higher Engineering Mathematics", B.V. Ramana, McGraw Hill Education 5. "Engineering Mathematics", S. Pal & S.C. Bhuria, Oxford University Press
3ANU7	**Introduction to Aeronautics Lab**
	• Acquaintance with the concept of static stability and control • Depiction of the use of aircraft primary control surfaces along with their locations on aircraft • Smoke visualization over cylinder and airfoil section to show boundary layer separation • Demonstration of foldable landing gear and damping in landing gear • Illustration of different types of UAVs • Review of different classes of flying vehicles • To study various types of engines used in aircraft • Discussion on Aircraft Traffic Control System along with its demonstration of its working • Study of constructional details of aircraft fuselage and wings • Display of different types of high lift devices and drag inducing devices
3ANU8	**Fluid Mechanics Lab**
	• Determination of meta-centric height of a given body • Determination of C_d, C_v & C_c for given orifice • Calibration of contracted rectangular notch and triangular notch and determination of flow rate • Determination of velocity of water by Pitot tube • Verification of Bernoulli's theorem • Calibration and flow rate determination using venturimeter and orificemeter • Determination of head loss in given length of pipe • Determination of the Reynolds number for laminar, turbulent and transient flow in pipe • Determination of coefficient for minor losses in pipes • Measurement of velocity distribution in a pipe and calculation of discharge • Measurement of boundary layer velocity profile over a flat plate and to determine the boundary layer thickness

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	• Experiments on potential flow analogy (Hele-Shaw flow) REFERENCE BOOKS:- 1. "Experiments in Fluid Mechanics", Sarbjit Singh, PHI Learning 2. "Laboratory Experiments in Fluid Mechanics", K.R. Arora, Standard Publications 3. "Fluid Mechanics and Machinery Laboratory Manual", N. Kumara Swamy, Charotar Publishing House Pvt. Ltd.
3ANU9	**Mechanics of Solids Lab**
	• Introduction to Universal Testing Machine • Use of Izod Impact Tester to measure impact loads • Calculation of Young's modulus of aluminum and steel • Determination of fracture strength and fracture pattern of ductile & brittle materials • Testing torsion load using Torsion Tester • Measurement of buckling load for columns • Performing tensile test and characterizing elastic limit, strain hardening, necking and yield point • Compression testing of a metal chip and calculation of compressive strength • Shear testing • Bending test and determination of Young's Modulus of Elasticity via deflection of beam • Performing fatigue test on a given material and to determine its fatigue strength • Creep testing and its significance
3ANU10	**Aircraft Materials Lab**
	• Characterization of important engineering materials and crystal structures • Demonstration of brittle and ductile fracture • Illustration of micro structures of steel using charts • Calculation of hardness using Rockwell Hardness Tester • Calculation of hardness using Brinell hardness Tester • Calculation of hardness using Vickers Hardness Tester VM-50

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	• Heat treatment experiments such as annealing, quenching, case hardening and their effect on hardness • Effect of carbon percentage on the hardness of steel • Study of Fe-C diagram • Depiction of various crystal structures and dislocations through models • Introduction to NDT methods
3ANU11	**Professional Skill Lab**
	Personality Assessment Skills: Personal SWOT analysis activities, leveraging personal strengths, self-evaluation, self-criticism, self-discipline; Mock interviews. **Time Management Skills**: Learning methodology for achieving targets and setting priorities. **Conflict Management Skills**: Learning negotiation and conflict resolution skills through simulation exercise. **Leadership Skills:** Assertiveness, innovation & creativity; Discussions on successful leaders and entrepreneurs. **Motivational Skills**: Motivational theories and their practical applications, ability to motivate self and others. **Stress Management Skills**: Practice different methods of stress management; Introduction to Yoga & Pranayama, use of prayer and meditation; Effective use of music for relieving stress and enhancing concentration & consistency. **Group Dynamics:** Group discussion, video samples of mock GD; Role plays; In-basket exercises. **Behavioural Skills**: Attitude and altitude; Lateral thinking; Psychometrics; Case studies and video samples. TEXT BOOK:- 1. "Developing Management Skills", D.A. Whetten & K.S. Cameron, Pearson Education REFERENCE BOOKS:- 1. "The Art of Conflict Management: Achieving Solutions for Life, Work, and Beyond", Michael Dues, The Great Courses 2. "Effective Communication Skills", Dalton Kehoe, The Great Courses

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	3. "Leadership Skills that Inspire Incredible Results", Fred Halstead, Brilliance Audio 4. "The Everything Stress Management Book: Practical Ways to Relax, Be Healthy, and Maintain Your Sanity", Eve Adamson, Adams Media Corporation 5. "Time Management from the Inside Out", Julie Morgenstern, Holt Paperbacks
3ANUDC	**Discipline & Extra Curricular Activities**
	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 4th Semester

Codes	Syllabus
4ANU1	**Aerodynamics – I**
	Basic Fluid Mechanics Concepts: Streamlines and streamfunction; Vorticity, circulation, relation between circulation and vorticity; Kelvin's theorem; Helmholtz theorems. **Potential Flow:** Velocity potential; Laplacian flow, principle of superposition; Elementary flows: uniform flow, source, sink, vortex & doublet; Potential flow past stationary and rotating circular cylinder, d'Alembert paradox, Magnus effect; Kutta-Joukowski theorem; Blasius theorem. **Flow over Airfoils:** Airfoil geometry, angle of attack, sectional forces and moment coefficients, centre of pressure and aerodynamic centre; Kutta condition; Introduction to conformal mapping, Kutta-Joukowski transformation; Thin Airfoil Theory, Theodorsen's condition; Real flow effects, effect of angle of attack on pressure distribution, airfoil stall, profile drag. **Flow over Finite Wings:** Wing geometry, forces and moment coefficients; Wingtip vortices, downwash, induced drag; Lifting Line Theory and its limitations, elliptical and general lift distribution; Simplified horseshoe vortex; Qualitative discussion of flow over delta wings. **Experimental Aerodynamics:** Components of wind tunnel, flow quality; Correlation of experimental results to actual prototypes, effect of Reynolds number and freestream turbulence; Flow visualization techniques, Basics of pressure, velocity and force measurement. TEXT BOOKS:- 1. "Fundamentals of Aerodynamics", J.D. Anderson, McGraw-Hill Higher Education 2. "Aerodynamics for Engineering Students", E.L. Houghton, P.W. Carpenter, S. Collicott & D. Valentine, Elsevier REFERENCE BOOKS:- 1. "Aerodynamics for Engineers", J.J. Bertin & R.M. Cummings, Pearson Education India

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	2. "Theoretical Aerodynamics", E. Rathakrishnan, John Wiley & Sons 3. "Basic Aerodynamics: Incompressible Flow", G.A. Randro, H.M. Macmohan & R.L. Roach, Cambridge University Press 4. "Low Speed Aerodynamics", K. Ghosh, PHI Learning 5. "Flight Vehicle Aerodynamics", M. Drela, MIT Press
4ANU2	**Engineering Thermodynamics**
	Fundamental Concepts: Thermodynamic system and control volume; Open, closed & isolated systems, thermodynamic properties, state and path variables, processes & cycles; Temperature & zeroth law of thermodynamics; Quasi-static process; Equation of state of perfect gas, difference between gas & vapour. **First Law of Thermodynamics**: First law for a closed system undergoing a change of state, heat & work, mechanical & non-mechanical forms of work, change in internal energy, heat transferred during various thermodynamic processes, P-V diagrams; First law applied to flow processes (control volume systems). **Second Law of Thermodynamics**: Kelvin-Plank & Clausius statements, heat engines, refrigerator & heat pump; Perpetual motion machines; Reversible & irreversible processes, availability, irreversibility; Introduction to entropy, principle of increase of entropy, Clausius inequality; Carnot cycle; Maxwell's relations. **Properties of Steam:** Critical state, sensible heat, latent heat, saturated & superheated steam, wet steam, dryness fraction, internal energy of steam, Mollier chart; Work & heat transfer during various thermodynamics processes with steam as working fluid; Clausius-Clapeyron equation and Joule-Thomson coefficient. **Air Standard Cycles:** Otto cycle; Diesel cycle; Stirling & Ericsson cycle; Brayton cycle; Joule cycle. **Vapour Cycles**: Simple & modified Rankine cycle with reheat & regeneration. TEXT BOOK:- 1. "Thermodynamics: An Engineering Approach", Y.A. Cengel & M.A. Boles, McGraw Hill Education 2. "Engineering Thermodynamics", P.K. Nag, McGraw Hill Education

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	REFERENCE BOOKS:- 1. "Fundamentals of Classical Thermodynamics", G.J. Van Wylen and R.E. Sonntag, John Wiley & Sons 2. "Thermodynamics", W.C. Reynolds & H.C. Perkins, McGraw-Hill 3. "Engineering Thermodynamics: Work and Heat Transfer", G. Rogers and Y. Mayhew, Longman Scientific 4. "Fundamentals of Engineering Thermodynamics", M.J. Moran & H.N. Shapiro, John Wiley & Sons Inc. 5. "Fundamentals of Engineering Thermodynamics", E. Rathakrishnan, Prentice-Hall of India
4ANU3	**Aircraft Structures – I**
	Introduction: Features of aircraft structures, monocoque and semi-monocoque structures, structural idealization, nomenclature & layout, functions of different structural members; Static equilibrium, statically determinate and indeterminate structures; Concept of static stability. **Statically Determinate Structures:** Analysis of framed structures; Planar truss analysis— method of joints, method of sections, method of moments; Space truss analysis, 3d truss tension coefficients. **Statically Indeterminate Structures:** Degree of indeterminacy; Bending & tension of fixed beams, composite beam, stress resultants, modulus weighted section properties; Clapeyron's three moment equation; Moment distribution method. **Deformations due to Loading:** Differential equation of the elastic curve due to composite loading, double integration and moment area methods; Conjugate beam method; Macaulay's method; Principle of superposition. **Energy Methods:** Work and energy principles, strain energy and complementary strain energy; Principal of virtual work, Principal of virtual displacement; Maxwell's Reciprocal theorem; Potential and complementary potential theorems; Castigliano's theorem, unit load method, application of energy principles in analysis of determinate and indeterminate structures. **Failure Theories:** Maximum principle stress theory; Maximum principle strain theory; Distortion Theory; Maximum strain energy theory; Octahedral shear stress theory; Fatigue; Creep; Application to aircraft structural problems. TEXT BOOKS:-

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	1. "Aircraft Structures for Engineering Students", T.H.G. Megson, Butterworth-Heinemann 2. "Analysis of Aircraft Structures : An Introduction", B.K. Donaldson, Cambridge University Press REFERENCE BOOKS:- 1. "Theory and Analysis of Flight Structures", R.M. Rivello, McGraw-Hill 2. "Introduction to Aerospace Structural Analysis", D.H. Allen & W.E. Haisler, John Wiley & Sons 3. "Aircraft Structures", D.J. Peery, Dover Publications Inc. 4. "Understanding Aircraft Structures", J. Cutler & J. Liber, Wiley-Blackwell 5. "Fundamentals Of Aircraft Structural Analysis", H.D. Curtis, McGraw-Hill Higher Education
4ANU4	**Theory of Machines**
	Kinematics: Links, pairs, mechanisms, four bar chain and its inversions; Velocity and acceleration, Klein's construction, Coriolis component; Instantaneous center method, pantograph; Scott-Russel, Tchbeicheff straight line, indicator diagram mechanisms. **Friction:** Laws of static, dynamic and rolling friction, dry and viscous friction; Inclined plane and screw jack; Pivots, clutches; Brakes: Band, block and band & block brakes, braking action. **Dynamometers:** Absorption and transmission type dynamometers, prony, rope and hydraulic dynamometers. **Gears:** Laws of gearing, gears terminology; Interference, undercutting and minimum number of teeth on pinion in contact with gear; Spur, helical, bevel gear, rack and pinion mechanism. **Gear Trains:** Simple, compound, reverted and epicyclic gear trains, analytical and tabular methods for velocity ratio; Gear boxes. **Gyroscope:** Principle of gyroscopic couple, effect of gyroscopic couple and centrifugal force on airplanes taking a turn. **Balancing:** Balancing of rotating masses; Balancing of reciprocating masses; Balancing of inline engines and V-engines. TEXT BOOKS:-

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	1. "Theory of Machines", S.S Rattan., McGraw Hill 2. "Theory of Machines and Mechanisms", Uicker, Pennocle & Shigley, Oxford University Press REFERENCE BOOKS:- 1. "Theory of Mechanisms and Machines", A. Ghosh, Affiliated East West Press 2. "Theory of Machines", Thomas Bevan, Pearson Education 3. "Mechanism and Machine Theory", A. G. Ambekar, Prentice-Hall Of India 4. "Theory of Mechanisms and Machines", Sharma & Purohit, Prentice-Hall Of India 5. "Theory of Machines", R.S. Khurmi & J.K. Gupta, S. Chand
4ANU5	**Machine Design**
	Materials: Mechanical Properties; Selection of material from properties and economic aspects. **Manufacturing Considerations**: Standardization, interchangeability, limits, fits, tolerances and surface roughness, BIS. **Design for Strength:** Allowable stresses, detailed discussion on factor of safety; Introduction of various design considerations like strength, stiffness, weight, cost, space etc.; Modes of failure, strength and stiffness considerations; Stress concentration, causes and mitigation. **Design of Members in Bending:** Beams, levers. **Design of Members in Torsion**: Shafts and shaft couplings, design of keys. **Design of Bearing:** Bearing classification, Methods of lubrication, hydrodynamic, hydrostatic, boundary etc.; Journal bearing, minimum film thickness, Sommerfield number, thermal equilibrium; Selection of anti-friction bearings for different load cycles, bearing life, static & dynamic load carrying capacity. **Fatigue Considerations in Design:** Variable load, loading pattern, endurance stresses; Influence of size, surface finish, notch sensitivity and stress concentration; Goodman line, Soderberg line & Gerber line; Design of machine members subjected to combined, steady and alternating stresses; design of shafts under variable stresses, bolts subjected to variable stresses.

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	TEXT BOOKS:- 1. "Design of Machine Elements", V.B. Bhandari, McGraw Hill Education 2. "Shigley's Mechanical Engineering Design", R.G. Budynas & J.K. Nisbett, McGraw Hill Education REFERENCE BOOKS:- 1. "Analysis and Design of Machine Elements", V.K. Jadon & S. Verma, I.K. International Publishing House Pvt. Ltd. 2. "A Text Book of Machine Design", A. Karwa, Laxmi Publication 3. "Machine Design", Hall, Holwenko & Laughlin, Schaum's Outlines Series, McGraw Hill 4. "Mechanical Machine Design", Bahl & Goel, Standard Publishers Distributors 5. "A Textbook of Machine Design", R.S. Khurmi & J.K. Gupta, S. Chand
4ANU6	**Advanced Engineering Mathematics – II**
	Complex Analysis: Differentiability and analytic functions; Cauchy-Riemann equations (in Cartesian and polar forms), harmonic functions; Conformal mapping; Complex Line integral, M-L inequality; Cauchy theorem, Cauchy integral formulae; Taylor series and Laurent series; Singularities and zeros, residues at poles and infinity, residues at isolated essential singular point; Cauchy residue theorem, evaluation of real definite integrals and improper integrals. **Special Functions**: Legendre's function, generating function, simple recurrence relations, orthogonal property; Bessel's functions of first and second kind, generating function, simple recurrence relations, orthogonal property. **Statistics & Probability**: Basic concepts of probability, conditional probability; Baye's theorem; Random variable and distributions: Discrete and continuous random variables, moments, expectation, moment generating function; Binomial, Poisson and normal distribution. TEXT BOOKS:- 1. "Advanced Engineering Mathematics", R.K. Jain & S.R.K. Iyengar, Narosa Publications 2. "Introduction to Probability and Statistics", S. Lipschutz & J.J. Schiller, McGraw Hill Education REFERENCE BOOKS:-

	1. "Advanced Engineering Mathematics", I. Kreyszig, Wiley India 2. "Advanced Engineering Mathematics", D. Zill & W. Wright, Jones & Bartlett India Private Limited 3. "Complex Variables and Applications", J.W. Brown & R.V. Churchill, McGraw Hill Education 4. "Probability and Statistics", M. Spiegel, J. Schiller & R.A. Srinivasan, McGraw Hill Education 5. "Higher Engineering Mathematics", B.V. Ramana, McGraw Hill Education
4ANU7	**Aerodynamics Lab**
	• Study of components of subsonic wind tunnel and its calibration • Measurement of pressure distribution over smooth and rough cylinder • Measurement of pressure distribution over symmetric and cambered airfoils • Force measurement using strain guage balance over models of different shapes • Flow visualization of flow over a delta wing at different incidences • Smoke flow visualization over airfoil and cylinder • Boundary layer measurements over flat plate • Calculation of displacement thickness over airfoil at different locations • Calibration of hot wire anemometer and freestream turbulence measurement • Use of pressure sensors for pressure measurement • Study of velocity measurement using LDV & PIV • Characterization of subsonic jets TEXT BOOKS:- 1. "Instruments, Measurements and Experiments in Fluids", E. Rathakrishnan 2. "Low-Speed Wind Tunnel Testing", J.W. Barlow, W.H. Rae & Alan Pope, John Wiley & Sons REFERENCE BOOKS:- 1. "Fluid Mechanics Measurements", R. Goldstein, CRC Press 2. "Experimental Aerodynamics", S. Discetti & Andrea Ianiro, CRC Press 3. "Experiments in Aerodynamics", S.P. Langley, Hardpress Publishing

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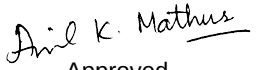
4ANU8	**Manufacturing Technology Lab**
	<u>Machine Shop</u> • Study of lathe machine, lathe tools, cutting speed, feed and depth of cut • To perform step turning, knurling and chamfering on lathe machine as per drawing • Taper turning by tailstock offset method as per drawing • To cut metric thread as per drawing • To perform square threading, drilling and taper turning by compound rest as per drawing • To study shaper machine and its mechanism • To study the milling machine, milling cutters, indexing heads and indexing methods and to prepare a gear on milling machine • Study of single point cutting tool geometry and to grind the tool as per given geometry **<u>Foundry Shop</u>** • To prepare mould of a given pattern requiring core and to cast it in aluminum • Moisture test and clay content test • Strength test (compressive, tensile, shear transverse etc. in green and dry conditions) • Hardness test (mould and core) • Permeability test • A.F.S. sieve analysis test **<u>Welding Shop</u>** • Hands-on practice on spot welding • Hands-on practice on submerged arc welding • Hands-on practice on metal inert gas welding (MIG) and tungsten inert gas welding (TIG) REFERENCE BOOKS:- 1. "Mechanical Workshop Practice", K.C. John, Prentice Hall India Learning Private Limited 2. "Workshop Practice", Swarn Singh, S.K. Kataria & Sons



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	3. "Elements of Workshop Technology", S.K. Hajra Choudhury & Nirjhar Roy, Media Promoters & Publishers Pvt. Ltd. 4. "A Textbook of Workshop Technology", D. Dhounchak & L.K. Biban, White Falcon Publishing 5. "Workshop Practice", H.S. Bawa, McGraw Hill Education
4ANU9	**Aircraft Structures Lab**
	• Study of construction of fuselage and identification of primary load carrying members • Study of construction of wings, ailerons, flaps, slits, slats and spoilers • Study of construction of empennage, stabilizers, rudders adjusting tabs etc. with detail of honeycomb structure • Study of construction of landing gears and wheel turning mechanism • Study of aileron control linkages including artificial feel mechanism, booster and manual controls and their adjustments • Measurement of forces in statically indeterminate force system • Deflection of beams with various end conditions for different load • Determination of compressive strength of thin plates • Verification of Maxwell's Reciprocal theorem & principle of superposition • Measurement of strain using strain gauges • Shear centre location for open and closed sections • Estimation of the location of principle axes for a given section • Compression tests on long and short columns and determination of buckling load • Calibration of photoelastic materials • Dye penetrant testing for surface crack detection
4ANU10	**Object Oriented Programming Lab**
	• Use of functions, arrays, strings etc. • Use of nested loops in applications • Brief introduction to pointers and referencing • Defining class and objects; use of objects as function parameters; friend functions • Different types of inheritance • Constructors and destructors

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	• Function and operator overloading • Introduction to algorithms such as searching algorithms (linear search and binary search) and sorting algorithms TEXT BOOKS:- 1. "Object Oriented Programming with C++", E. Balagurusamy, McGraw Hill Education 2. "Object Oriented Programming in C++", Robert Lafore, Pearson Education India REFERENCE BOOKS:- 1. "Let Us C++", Y.P. Kanetkar, BPB Publications 2. "The C++ Programming Language", Bjarne Stroustrup, Pearson Education India 3. "C++: The Complete Reference", Herbert Schildt, McGraw Hill Education 4. "C++ Standard Library: A Tutorial and Reference", N.M. Josuttis, Addison-Wesley Professional 5. "C++ Programming Simplified", V. Thada, College Book Centre
4ANU11	**Contemporary Challenges**
	Group discussions and presentations on various contemporary issues such as:- • Economic policies of nations affecting large number of people • Technological advancements and their consequences • Need for sustainable development • National and international policies of various countries • Civil and human rights • Education policy of state • Effect of historic and geographic conflicts on present society • Debates in political theories • Socio-cultural transformations and their effects REFERENCE BOOKS:-

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	1. "Indian Ethics: Classical Traditions and Contemporary Challenges", P. Bilimoria, J. Prabhu & R.M. Sharma, Ashgate Publishing Ltd. 2. "Globalisation and the Challenges of Development in Contemporary India", S. Venkateswar & S. Bandyopadhyay, Springer 3. "Contemporary Challenges in Regulating Global Crises", M. Findlay, Springer Nature 4. "Indian Democracy Contemporary Challenges", N.P. Chaudhary & A.K. Ojha, Pragun Publication 5. "Contemporary Challenges in Securing Human Rights", Corinne Lennox, Institute of Commonwealth Studies
4ANUDC	**Discipline & Extra-Curricular Activities**
	As per UD, RTU norms

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Syllabus of B.Tech. Aeronautical Engineering, 5th Semester

Codes	Syllabus
5ANU1	**Aerodynamics – II**
	Basic Concepts: Compressibility; Laws of thermodynamics, perfect gas, internal energy, enthalpy, entropy; Mach number, fundamental difference between subsonic and supersonic flow, Mach angle, shock and Mach waves. **Steady One-Dimensional Isentropic Flow:** Continuity, momentum and energy conservation equations; Stagnation temperature and pressure; Expression for speed of sound; Area-velocity relation, flow in nozzles & diffusers, effect of back pressure. **Shocks:** Normal shock, normal shock relations for perfect gas, Prandtl relation; Rankine-Hugoniot equation; Moving normal shock; Oblique shocks, oblique shock relations, strong and weak shock solutions, shock polar, detached shock. **Expansion Waves:** Expansion fan, Prandtl-Meyer function, reflection and interaction of shocks and expansion waves. **Non-Isentropic 1D flow:** Rayleigh flow; Fanno flow. **Airfoils in Compressible flow:** Critical Mach number and critical pressure coefficient, drag divergence Mach number; Shock boundary layer interaction, shock induced separation; Whitecomb area rule, supercritical airfoil, swept and delta wings, supersonic aerofoils, wave drag; Similarity rules; Supersonic thin airfoil theory. **Introduction to Hypersonic flow:** Distinguishing phenomena in hypersonic flow; Basic hypersonic shock and expansion relations; Newtonian model. **Experiments in Compressible Flow:** Transonic, supersonic and hypersonic tunnels and their peculiarities; Blowdown, indraft and continuous wind tunnels; Shock tubes; Pressure measurement; Velocity measurement; Optical methods of flow visualization. TEXT BOOKS:-

	1. "Modern Compressible Flow", J.D. Anderson Jr., McGraw Hill 2. "Gas Dynamics", E. Rathakrishnan, Prentice Hall of India Pvt. Ltd. REFERENCE BOOKS:- 1. "The Dynamics and Thermodynamics of Compressible Flow", A.H. Shapiro, Wiley India 2. "Elements of Gas Dynamics", H.W. Liepmann & A. Roshko, Wiley & Sons 3. "Fundamentals of Gas Dynamics", R.D. Zucker & O. Biblarz, John Wiley & Sons 4. "Compressible Fluid Flow", P.H. Oosthuizen & W.E. Carscallen, McGraw-Hill 5. "Fundamentals of Gas Dynamics", M.J. Zucrow & J.D. Hoffman, Wiley India Private Limited
5ANU2	**Aircraft Performance**
	Atmosphere: Need to define standard atmosphere; International Standard Atmosphere; Stability of atmosphere; Equivalent, calibrated and indicated airspeed; Primary flight instruments, ASI, VSI, turn-bank indicator. **Aerodynamic Characteristics:** Forces and moments acting on a flight vehicle, variation of aerodynamic coefficients with angle of attack, Reynolds number and Mach number; Effect of aspect ratio, planform, sweep, taper and twist on aerodynamic characteristics; Different types of drag, drag polar, design methods to reduce drag; Variation of thrust, power and SFC with velocity and altitudes for air-breathing engines. **Steady Level Flight:** Equations of motion; Thrust and power required for level unaccelerated flight; Maximum thrust and power available for jet engine and propeller engine, variation of thrust/power available and required with altitude; Maximum level flight speed, conditions for minimum drag and minimum power required; Stalling speed; Range and endurance of jet and propeller engine airplanes, condition for maximum range and endurance; Effect of altitude, weight and wind. **Climbing Flight:** Unaccelearated climb; Excess power; Maximum rate of climb and steepest angle of climb, time to climb, climb hodograph; Absolute and service ceilings; Accelerated rate of climb; Energy manoeuvrability. **Gliding Flight:** Steady descent, equilibrium glide angle, equilibrium glide velocity; Minimum rate of sink and shallowest angle of glide, maximum gliding range; Glide hodograph.

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	Take-off & Landing Performance: Equations of motion during take-off and landing; Estimation of take-off and landing distances; Effect of head, tail and cross winds; Thrust augmentation, reverse thrust, jet assisted take-off system, spoilers. **Manoeuvring Flight:** Level coordinated turning flight in horizontal plane, bank angle, load factor, V-n diagram; Minimum turn radius; Maximum sustained and attained turn rate; Turn in vertical plane, pull-up and pull-down manoeuvres. **High Lift Devices:** Different types of trailing edge flaps; Leading edge devices; Boundary layer control; Powered lift. TEXT BOOKS:- 1. "Aircraft Performance and Design", J.D. Anderson Jr., McGraw Hill 2. "Aircraft Performance", W.A. Mair & D.L. Birdsall, Cambridge University Press REFERENCE BOOKS:- 1. "Aircraft Performance", M. Saarlas, John Wiley & Sons 2. "Fundamentals of Flight", R.S. Shevell, Pearson Education Limited 3. "Airplane Aerodynamics and Performance", Jan Roskam & Chuan-Tau Edward Lan, DAR Corporation 4. "Aircraft Performance: An Engineering Approach", M.H. Sadraey, CRC Press 5. "Flight Performance of Aircraft", S.K. Ojha, AIAA Education Series
5ANU3	**Heat Transfer**
	Introduction: Definitions of heat and heat transfer, difference between heat transfer and thermodynamics; Basic modes and laws of heat transfer, engineering applications of heat transfer. **Conduction:** Fourier's law of heat conduction; Heat conduction equation for homogeneous isotropic materials in different coordinate systems, significance of thermal diffusivity. **Simple One-Dimensional Steady Heat Conduction Problems:** Plane wall temperature distribution and heat transfer, electrical analogy of heat transfer, composite walls, critical thickness of insulation; Steady one-dimensional heat conduction with heat generation; Analysis of fins having variable and constant cross-sectional area, fin efficiency and fin effectiveness.

	Steady State Two-Dimensional Heat Conduction Problems (with no internal sources): Heat conduction in a rectangular bar by method of separation of variables. **Unsteady Heat Conduction:** Definitions of lumped and distributed systems; Definition of Biot number and its physical implication, Biot number limit for lumped system. **Forced Convection:** Fundamentals, no-slip and no temperature-jump conditions, local and average heat transfer coefficients, Nusselt number; Forced convection over a flat plate, momentum and thermal boundary layer, Prandtl number and its range for various fluids. **Natural Convection:** Physical mechanism of natural convection; Steady laminar free convection from an isothermal vertical plate, similarity parameters, correlations of local and average Nusselt numbers, Grashof number. **Boiling:** Pool boiling, saturated pool boiling curve, critical heat flux correlation, minimum heat flux and film boiling correlations. **Condensation:** Dropwise and film condensation; Nusselt's theory of laminar film condensation on a vertical plate. **Heat Exchangers:** Parallel flow & counterflow heat exchangers; Overall heat transfer coefficient, Fouling factor; LMTD, effectiveness of heat exchangers. **Thermal Radiation:** Radiation characteristics, Planck's law, Stefan-Boltzmann law, Wien's displacement law; Intensity of total and spectral radiation, relation to irradiation; Absorptivity, reflectivity and transmissivity, emissivity, definition of black, gray & diffuse surfaces; Kirchhoff's law; View Factor, reciprocity theorem, F_{ij} for plane, convex and concave surfaces. TEXT BOOKS:- 1. "Principles of Heat Transfer", F. Kreith, R.M. Manglik & M.S. Bohn, 2. "Principles of Heat and Mass Transfer", F.P. Incropera, D.P. Dewitt, T.L. Bergman & A.S. Lavine, Wiley India REFERENCE BOOKS:- 1. "Heat and Mass Transfer: Fundamentals and Applications", Y.A Cengel & A.J. Ghajar, McGraw-Hill Education

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	2. "Heat Transfer", J.P. Holman & S. Bhattacharyya, McGraw Hill Education 3. "Heat and Mass Transfer", P.K Nag, McGraw Hill Education 4. "Heat Transfer", P.S. Ghoshdastidar, Oxford University Press 5. "Introduction to Heat Transfer", S.K. Som, Prentice Hall India Learning Private Limited
5ANU4	**Elements of Vibration**
	Basics of Vibration: Scope of vibration, important terminology and classification; Degrees of freedom, harmonic motion; Vectorial representation, complex number representation. **Undamped Vibrations of Single Degree of Freedom System:** Derivation of equation of motion for one-dimensional longitudinal, transverse and torsional undamped free vibrations using Newton's second law; D' Alembert's principle and principle of conservation of energy; Compound pendulum and centre of percussion. **Damped Vibrations of Single Degree of Freedom System:** Viscous damping, underdamped, critically damped and overdamped systems, damping ratio, logarithmic decrement; Vibration characteristics of Coulomb damping and Hysteretic damping. **Forced Vibrations of Single Degree of Freedom System:** Forced vibration with constant harmonic excitation, steady state and transient parts; Frequency response curves and phase response curve; Forced vibration due to excitation of support. **System with Two Degrees of Freedom:** Principle mode of vibration, mode shapes; Undamped forced vibrations of two degrees of freedom system with harmonic excitation; Vibration absorber, undamped dynamic vibration absorber and centrifugal pendulum absorber. **Multiple Degree of Freedom Systems:** Exact analysis of undamped free vibrations; Approximate methods. **Vibrations of Continuous Systems:** Transverse vibration of a string; Longitudinal vibration of a bar; Torsional vibration of a shaft and flexural vibrations of a beam. TEXT BOOKS:- 1. "Mechanical Vibrations", S.S Rao, Pearson Education

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	2. "Elements of Vibration Analysis", L. Meirovitch, McGraw-Hill REFERENCE BOOKS:- 1. "Mechanical Vibrations", R. Venkatachalam, Prentice Hall India Learning Private Limited 2. "Mechanical Vibrations: Theory and Applications", Kelly, S.G., Cengage Learning 3. "Theory of Vibrations with Applications", W.T. Thomson, M.D. Dahleh & C. Padmanabhan, Pearson Education 4. "Principles of Vibration", B.H Tongue, Oxford Publication 5. "Mechanical Vibrations", W.J. Palm III, Wiley
5ANU5	**Aircraft Systems**
	Airplane Control Systems: Conventional systems; Power-assisted and fully-powered flight controls; Push-pull rod system, flexible push-pull rod system components; Modern control systems, digital fly-by-wire systems, autopilot system technology; Introduction to communication and navigation systems; Instrument landing systems. **Hydraulic Systems:** Components; Hydraulic system controllers, modes of operation; Pneumatic systems, components, working principles and advantages. **Landing Gear Systems:** Classification, shock absorbers, retractive mechanism; Anti-skid system, wheels and brake, steering systems, indications. **Fuel Systems:** Types of fuels, their properties and testing, colour codes, fuel requirements; Pumps, fuel transfer systems, fuel tanks, plumbing, valves, indications and warnings; Aircraft fuel dumping/ jettison system. **Auxiliary System:** Various types systems, components and operation of air-conditioning system; Pressurization system; Oxygen systems; Fire protection systems; De-icing and anti-icing systems; Seat safety system: Ejection seats, survival packs, parachutes, pilot's personal equipment, doors, windows, emergency exits and seat belts. **General Maintenance Practices:** Jacking, levelling and mooring, refuelling and defueling of aircraft, safety precautions; Hydraulic and fluid systems precautions against contamination; Identification colour coding, symbols and other markings to identify the fluid systems.

	TEXT BOOKS:- 1. "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", I. Moir & A. Seabridge, Wiley-Blackwell 2. "Aircraft Systems", D.A. Lombardo, McGraw Hill REFERENCE BOOKS:- 1. "Aircraft Instruments", E.H.J. Pallett, Pearson Education 2. "Aircraft Instrumentation and Systems", S. Nagabhushana, I.K. International Private Limited 3. "Aircraft Structures and Systems", Ray Wilkinson, Mechaero Publishing 4. "Aircraft Display Systems", M. Jukes, AIAA 5. "Aircraft Electrical Systems, Hydraulic Systems and Instruments", R.H. Drake, Sportsman's Vintage Press
5ANU6.1	**Rotorcraft Dynamics**
	Introduction: Basic features and layout of different rotorcrafts, main rotor, gearbox, tail rotor, power plant to drive main and tail rotor; Generation of lift, geometry of the rotor, blade loading, effect of solidity, profile drag, compressibility etc.; Blade area required, number of blades, power losses, rotor efficiency; Flapping, feathering and lagging motions of rotor blade. **Rotor Aerodynamics in Vertical Flight:** Momentum theory for hover, vertical climb and vertical descent; Induced-velocity curve; Autorotation; Ground effect; Thrust approximation, ideal twist, blade mean lift coefficient, power approximation, tip losses. **Rotor Aerodynamics in Forward Flight:** Equivalence of flapping and feathering, asymmetry of lift; Momentum theory; Wake analysis; Blade element theory. **Performance:** Hover and vertical flight; Forward level flight; Climb in forward flight, maximum rate of climb; Optimum and maximum level speed; Rotor limit envelope and prediction of accurate performance; Low drag helicopter speculations; High altitude operation. **Helicopter Trim Analysis:** Helicopter trim in forward flight, longitudinal trim; Effect of tail plane on trim; Lateral control to trim; Fixed and adjustable stabilizers.

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	Dynamic Stability and Control: Longitudinal equations of motion, longitudinal dynamic stability; Lateral dynamic stability; Auto-stabilization; Rotor control response; Differences between stability and control of airplane and helicopter. TEXT BOOKS:- 1. "Basic Helicopter Aerodynamics", J. Seddon, AIAA Series 2. "Helicopter Dynamics", A.R.S. Bramwell, John Wiley and Sons REFERENCE BOOKS:- 1. "Fundamental of Helicopter Aerodynamics", C. Venkatesan, CRC Press book 2. "Helicopter Performance, Stability and Control", R. W. Prouty, Krieger Publishing Company 3. "Principles of Helicopter Engineering", Jacob Shapiro, McGraw Hill 4. "The Helicopter and How It Flies", John Fay, Himalayan Books 5. "Principles of Helicopter Aerodynamics", G.J. Leishman, Cambridge University Press
5ANU6.2	**Smart Materials**
	Overview of Smart Materials: Introduction to smart materials, principles of piezoelectricty, single crystals vs. polycrystalline systems, piezoelectric polymers; Principles of magnetostriction, rare earth magnetostrictive materials, giant magnetostriction and magneto-resistance effect; Introduction to electro-active materials, electro-active polymers, ionic polymer, ionic polymer metal composites; Shape memory effect, shape memory alloys and polymers; Electro-rheological fluids, magneto-rhelological fluids. **Smart Sensors:** Piezeoelctric strain sensors, in-plane and out of plane sensing, shear sensing; Accelerometers; Magnetostrictive sensing, Villari effect, Matteuci effect and Nagoka-Honda effect, magnetic delay line sensing; Application of smart sensors for structural health monitoring, system identification using smart sensors. **Smart Actuators:** Modelling piezoelectric actuators, amplified piezo actuation; Magnetostrictive actuation, Joule effect, Wiedemann effect, magnetovolume effect, Magnetostrictive mini actuators; IPMC and polymeric actuators; Shape memory actuators; Active vibration control, active shape control, passive vibration control, hybrid vibration control.

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	Review of Composite Materials: Modelling laminated composites based on classical laminated plate theory, effect of shear deformation; Smart composites, dynamics of smart composite beam, governing equation of motion, finite element modelling of smart composite beams. **Advances in Smart Structures & Materials:** Self-sensing piezoelectric transducers; Energy harvesting materials; Autophagous materials; Self-healing polymers; Intelligent system design, emergent system design. TEXT BOOKS:- 1. "Smart Structures: Physical Behaviour, Mathematical Modelling and Applications", Paolo Gaudenzi, Wiley-Blackwell 2. "Smart Materials and Structures", M.V. Gandhi & B.S. Thompson, Springer REFERENCE BOOKS:- 1. "Smart Structures and Materials", Brian Culshaw, Artech House Publishers 2. "Smart Structures", P. Gauenzi, Wiley 3. "Smart Structures: Analysis and Design", A.V. Srinivasan & D.M. McFarland, Cambridge University Press 4. "Smart Materials & Structures: New Research", P.L. Reece, Nova Science Publishers Inc. 5. "Smart Material Systems and MEMS: Design and Development Methodologies", V.K.Varadan, K.J. Vinoy & S. Gopalakrishnan, Wiley
5ANU6.3	**Introduction to Robotics**
	Introduction: Brief history, types, classification and usage; Science and technology of robots. **Elements of Robots**: Joints, links, actuators and sensors; Position and orientation of a rigid body, homogeneous transformations; Types of transmissions; Different kinds of actuators: stepper, DC servo and brushless motors; Purpose of sensors, internal and external sensors; Common sensors: encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors and vision. **Kinematics of Serial Robots:** Introduction, direct and inverse kinematics problems, examples of kinematics of common serial manipulators; Inverse kinematics of constrained and redundant robots; Simulations and experiments.

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	Kinematics of Parallel Robots: Degrees of freedom of parallel mechanisms and manipulators, active and passive joints; Constraint and loop-closure equations, direct kinematics problem, mobility of parallel manipulators, closed-form and numerical solution; Inverse kinematics of parallel manipulators and mechanisms. **Velocity and Statics of Robot Manipulators:** Linear and angular velocity of links, velocity propagation; Manipulator Jacobians for serial and parallel manipulators, velocity ellipse and ellipsoids; Statics of serial and parallel manipulators. **Dynamics of Serial and Parallel Robots:** Mass and inertia of links; Lagrangian formulation for equations of motion for serial and parallel manipulators; Simulation (direct and inverse) of dynamic equations of motion, examples of a planar 2R and four-bar mechanism; Recursive dynamics. **Motion Planning and Control:** Joint and Cartesian space trajectory planning and generation; Classical control concepts using the example of control of a single link; Independent joint PID control, control of a multi-link manipulator, non-linear model based control schemes; Control of constrained manipulators, Cartesian control, force control and hybrid position/force control. TEXT BOOKS:- 1. "Robotics: Fundamental Concepts and Analysis", A. Ghosal, Oxford University Press 2. "Introduction to Robotics: Analysis, Control, Applications", S.B. Niku, Wiley REFERENCE BOOKS:- 1. "Introduction to Robotics: Mechanics and Control", J.J. Craig, Pearson 2. "Introduction to Robotics", S.K. Saha, McGraw-Hill 3. "Elements of Robotics", M. Ben-Ari & F. Mondada, Springer 4. "Robotics: Fundamental Concepts and Analysis", Ashitava Ghosal, Oxford 5. "Introduction to Robotics: Mechanics and Control", J.J. Craig, Pearson Education India
5ANU6.4	**Automobile Engineering** (Common with 5MEU6.1)
	Frame & Body: Layout of chassis, types of chassis frames and bodies, their constructional features and materials. **Clutches:** Single plate, multi-plate, cone clutch, semi centrifugal, electromagnetic, vacuum and hydraulic clutches; Fluid

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	coupling. **Brakes:** Classification and function; Mechanical, hydraulic, vacuum air and self-engineering brakes; Brake shoes and lining materials **Gear Boxes:** Sliding mesh, constant mesh, synchromesh and epicyclic gear boxes; Automatic transmission system; Hydraulic torque converter. **Drives:** Overdrive; Propeller shaft, universal joints; Differential, rear axle drives; Hotchkiss and torque tube drives; Rear axle types; Front wheel and all-wheel drive. **Tyres:** Tyre types, construction; Inflation pressure; Tyre wear and its causes; Re-treading of the tyre **Steering System:** Steering gear boxes, steering linkages, steering mechanism; Under and over steering; Steering geometry, effect of camber, caster, king pin inclination, toe in and toe out; Power steering; Integral and linkage types. **Suspension System:** Objective and requirements, suspension spring, front and rear suspension systems; Independent suspension system Shock absorbers. **Automotive Electrical System:** Battery construction, charging and testing, battery types; Starting and battery charging system, starter motor construction, types of drive; Alternator construction, regulation and rectification. **Ignition System:** Magneto and coil ignition systems; System components and requirements; Automotive lighting, wiring systems; Electrical instruments: head lamp, electric horn, fuel level indicator. **Automotive Air Conditioning:** Introduction, loads, air conditioning system components, refrigerants; Fault Diagnosis. **Automotive Safety:** Safety requirements, safety devices, air bags, belts, radio ranging, NVS (Night Vision System) GPS (Global Positioning System). TEXT BOOKS:- 1. "A Course in Automobile Engineering", R.P. Sharma, Dhanpat Rai & Sons

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	2. "Automobile Engineering", K. Singh, Standard Publications REFERENCE BOOKS:- 1. "A Text Book of Automobile Engineering", P.S. Gill, Katson Books 2. "A Text Book of Automobile Engineering", R.K. Rajput, Laxmi Publications 3. "The Automotive Chassis: Engineering Principles", J. Reimpell & H. Stoll, Butterworth Heinemann Ltd. 4. "Automobile Engineering", K. Ramakrishna, Prentice Hall India Learning Private Limited 5. "Automobile Engineering", A.K. Babu & A.P. Singh, S. Chand
5ANU7	**CAD Lab**
	• Introduction and different features of the CAD Software (AutoDesk Inventor/ SolidWorks/ CATIA) • 2-D Drafting • 3-D modelling • Assembly modelling • Feature modification and manipulation • Detailing • Surface modelling REFERENCE BOOKS:- 1. "AutoCAD 2019 for Beginners", Cadfolks, Createspace Independent Publishing Platform 2. "AutoCAD 2019 Beginners Guide", Amit Bhatt, Createspace Independent Publications 3. "Mastering AutoCAD 2019 and AutoCAD LT 2019", G. Omura & B.C. Benton, Wiley 4. "SolidWorks 2018 For Designers", Sham Tickoo, BPB Publications 5. "Catia V5-6r2017 For Designers", Sham Tickoo, Global Books & Subscription Services
5ANU8	**Heat Transfer Lab**
	• To determine thermal conductivity of insulating powders • To determine thermal conductivity of a good conductor of heat (metal rod) • To determine the individual thermal conductivity of different lagging in a lagged pipe

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	• To determine the total thermal conductivity and thermal resistance of the given compound resistance in series • To determine the heat transfer rate and temperature distribution for a pin fin • To determine the surface heat transfer coefficient for heated vertical cylinder in natural convection • To find the heat transfer coefficient in forced convection in a tube • To study and compare LMTD and effectiveness in parallel flow heat exchangers • To study and compare LMTD and effectiveness in counter flow heat exchangers • Determination of heat transfer coefficient in drop wise and filmwise condensation • To determine critical heat flux in saturated pool boiling • To measure the emissivity of the test plate surface • To determine Stefan Boltzmann constant of radiation heat transfer • To understand the importance and validity of engineering assumptions through lumped heat capacity method
5ANU9	**Elements of Vibration Lab**
	• To verify time period a simple pendulum • To determine radius of gyration of compound pendulum • To determine the radius of gyration of given bar by using bifilar suspension • To determine natural frequency of a spring mass system • To determine natural frequency of free torsional vibrations of single rotor system • To verify Dunkerley's rule • Performing the experiment to find out damping coefficient in case of free damped torsional vibration • To conduct experiment of trifilar suspension • Harmonic excitation of cantilever beam using electro-dynamic shaker and determination of resonant frequencies • Study of vibration measuring instruments Perform study of the following using Virtual Lab: http://www.vlab.co.in/ • Forced vibration of a cantilever beam with a lumped mass at free end • Harmonically Excited Forced Vibration of a Single DOF System • Forced Vibration of a Cantilever Beam with a Lumped Mass at Free End

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	• Harmonically Excited Forced Vibration of a Single DOF System
5ANU10	**Aircraft System Lab**
	• Control system 'rigging check' procedure • Aircraft 'symmetry check' procedure • 'Flow test' to assess of filter element clogging • 'Pressure test' to assess hydraulic external/internal leakage • Functional test of hydraulic actuator for its proper operation, leakage and load test • 'Pressure test' procedure on fuel system components • 'Brake torque load test' on wheel brake unit • Maintenance and rectification of snags in pneumatic, hydraulic and fuel systems components and on aircraft • Functional test of fire detection system on aircraft • Functional test of aircraft pressurization system on aircraft • Functional test of aircraft landing gear retraction system and its relevant indications in the cockpit • Study of combustion chambers of various engines
5ANU11	**Professional Ethics & Disaster Management**
	Human Values: Effect of technological growth and sustainable development; Profession and human values, values crisis in contemporary society; Nature of values, psychological values, societal values and aesthetic values, moral and ethical values. **Professional Ethics:** Professional and professionalism, professional accountability, role of a professional, ethic and image of profession; Engineering profession and ethics, technology and society, ethical obligations of engineering professionals; Roles of engineers in industry, society, nation and the world; Professional responsibilities, collegiality, loyalty, confidentially, conflict of interest, whistle blowing. **Disaster Management:** Understanding disasters and hazards related issues in society and environment, risk and vulnerability; Types of disasters, their occurrence/causes, impact and preventive measures. **Natural Disasters:** Hydro-meteorological based disasters like flood, flash flood, cloud burst, drought, cyclone, forest fires; Geological based disasters like earthquake, Tsunami, landslides, volcanic eruptions.

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	Man-Made Disasters: Chemical industrial hazards; Major power breakdowns; Traffic accidents; Fire hazards; Nuclear accidents; Disaster profile of Indian continent, case studies; Disaster management cycle and its components. Every student should perform a case study of a disaster and submit a summary report. TEXT BOOKS:- 1. "Professional Ethics", R. Subramanian, Oxford University Press 2. "Disaster Management", R. Subramanian, Vikas Publishing House REFERENCE BOOKS:- 1. "Professional Ethics and Human Values", M. Govindarajan, S. Natarajan & V.S. Senthilkumar, Prentice Hall India Learning Private Limited 2. "Disaster Science and Management", Tushar Bhattacharya, McGraw Hill Education 3. "Engineering Ethics: Concepts and cases", C.E. Harris, M.S. Pritchard & M.J. Rabins, Cengage Learning 4. "Disaster Management", Mrinalini Pandey, Wiley 5. "Disaster Management", Harsh K. Gupta, Universities Press
5ANUDC	**Discipline & Extra-Curricular Activities**
	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 6th Semester

Codes	Syllabus
6ANU1	**Aerospace Propulsion – I**
	Fundamentals of Air-Breathing Engines: Review of thermodynamic principles, basic principles of propulsion; History of air-breathing engines; Different types of air-breathing engines, functions of different engine components; Engine-aircraft matching; Methods of thrust augmentation. **Performance of Air-Breathing Engines:** Ideal cycles for turbojet, turboprop, turbofan, turboshaft and ramjet engines; ideal cycle analysis; Non-ideal cycle analysis, stage and component efficiencies; Thrust equation; Performance parameters of jet engines. **Inlets:** Internal flow and stall in subsonic inlets, boundary layer separation; Major features of external flow near a subsonic inlet; Diffuser performance; Supersonic inlets, starting problem in supersonic inlets, shock swallowing by variable area inlet or by overspeeding aircraft. **Centrifugal Compressor:** Operating principle, conservation of angular momentum, applications, advantages and disadvantages; Stage dynamics, velocity diagrams, cascade efficiency, performance characteristics; Stall and surge. **Axial Flow Compressor:** Euler's turbo-machinery equations, velocity diagram analysis, cascade action; Multi-staging; Degree of reaction; Radial equilibrium; Flow problems, compressor efficiency. **Axial Flow Turbine:** Types of turbines, performance parameters; Blade design principles; Axial turbine stage, stage efficiency; Turbine Performance; Blade stresses, blade cooling; Turbine and compressor matching. **Nozzles:** Flow in isentropic nozzles, nozzle choking; Nozzle efficiency, losses in nozzles; Overexpanded and underexpanded nozzles; Ejector and variable area nozzles; Thrust reversal. TEXT BOOKS:- 1. "Gas Turbine Theory", H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen & P.V. Straznicky, Prentice Hall

	2. "Mechanics and Thermodynamics of Propulsion", P. Hill & C. Peterson, Pearson Education REFERENCE BOOKS:- 1. "Aircraft Propulsion", Saeed Farokhi, Wiley-Blackwell 2. "Elements of Gas Turbine Propulsion", J.D. Mattingly, McGraw Hill Education 3. "Fundamentals of Jet Propulsion with Applications", R.D. Flack, Cambridge University Press 4. "Gas Turbines", V. Ganesan, McGraw Hill Education 5. "Gas Turbine Propulsion", D.P. Mishra, Viva Books
6ANU2	**Aircraft Stability and Control**
	Introduction: Static stability, dynamic stability, longitudinal, lateral and directional stability; Equations of motion. **Longitudinal Static Stability and Control:** Contribution of wing, horizontal tail and fuselage to total moment, canard configuration, flying wing configuration; Stick-fixed neutral point and static margin, stick-free neutral point, determination of neutral point by flight test, manoeuvre point; Power contribution to stability, elevator power, elevator angle to trim, elevator hinge movement, stick force and stick gearing, stick force gradients, aerodynamic balancing. **Directional Static Stability and Control:** Vertical tail contribution, fuselage contribution, wing contribution, propeller effect; Rudder power, yaw damping; Rudder-fixed and rudder-free directional stability, asymmetric power, pedal forces, rudder lock. **Lateral Static Stability and Control:** Effect of wing location, sweep and dihedral, fuselage and vertical tail; Coupling between rolling and yawing moments; Adverse yaw effects; Aileron reversal; Lateral control power; Roll damping, directional divergence. **Dynamic Stability and Control:** Euler angles, Equations of motion, stability & control derivatives; Decoupling of longitudinal and lateral-directional dynamics; Longitudinal modes; Lateral-directional modes; Autorotation and spin; Control response, impulse and step response; Controllability and Observability; Optimal control. TEXT BOOKS:- 1. "Flight Stability and Automatic Control" , R.C. Nelson, McGraw Hill Education

	2. "Flight Dynamics Principles", M.V. Cook, John Wiley & Sons Inc. REFERENCE BOOKS:- 1. "Performance, Stability, Dynamics and Control of Airplanes" , B.N. Pamadi, AIAA 2. "Airplane Performance, Stability and Control", C.D. Perkins & R.E. Hage, John Wiley & Sons 3. "Mechanics of Flight", R.H. Barnard, D.R. Philpott & A.C. Kermode, Prentice Hall 4. "Mechanics of Flight", W.F. Phillips, John Wiley & Sons 5. "Dynamics of Flight: Stability and Control", B. Etkin & L.D. Reid, John Wiley & Sons
6ANU3	**Aircraft Structures – II**
	Unsymmetrical Bending: Bending stresses in beams of unsymmetrical sections, general, principal axis and neutral axis methods; Bending stresses in beams of symmetric section with skew loads. **Shear Flow in Open Sections:** Thin-walled beams, concept of shear flow, shear centre; Shear flow distribution in symmetrical and unsymmetrical thin-walled sections. **Shear Flow in Closed Sections:** Bredt-Batho method, single and multi-cell structures; Shear flow in single and multi-cell under torsion, shear and bending; Shear centre of closed sections. **Buckling of Thin Plates:** Rectangular sheets under compression, local buckling stress of thin walled section; Thin walled column strength, crippling strength estimation; Buckling of sheet-stiffener combination, effective width. **Stress Analysis in Wing and Fuselage:** Loads on an aircraft, V-n diagram, shear force and bending moment distribution for semi-cantilever and other types of wings and fuselage; Shear and bending moment distribution for cantilever and semi-cantilever types of beams, thin-webbed beam with parallel and non-parallel flanges. TEXT BOOKS:- 1. "Aircraft Structures for Engineering Students", T.M.G. Megson, Butterworth-Heinemann 2. "Analysis and Design of Flight Vehicles Structures", E.H. Bruhn, Jacobs Publishing Inc.

	REFERENCE BOOKS:- 1. "Theory and Analysis of Flight Structures", R.M. Rivello, McGraw Hill 2. "Aircraft Structures", D.J. Peery & J.J. Azar, McGraw Hill 3. "Mechanics of Aircraft Structures", C.T. Sun, Wiley India Private Limited 4. "Airframe Stress Analysis and Sizing", M.C. Niu, Adastra Engineering Center 5. "Practical Stress Analysis for Design Engineers", Jean-Claude Flabel, Lake City Publishing Corporation
6ANU4	**Space Dynamics**
	Introduction: Definition of space, space environment, effect of space environment on materials of spacecraft structure; Solar system, celestial sphere, ecliptic, equatorial plane and equinoxes; History of space exploration, Space missions and role of launch vehicles and spacecraft, different types of earth orbits, types of spacecraft, spacecraft subsystems; Newton's law of gravitation, Kepler's laws; Vector differentiation, kinematics relative to rotating frames. **Two-body Problem:** Equation of relative motion, conservation of angular momentum and energy; Different types of trajectories, orbital elements; Lambert's theorem. **N-body Problem:** Equation of motion; Restricted three-body problem, Lagrangian points, concept of sphere of influence. **Orbital Manoeuvres:** Hohmann transfer, bielliptic transfer, plane change manoeuvres, combined manoeuvres, low thrust transfer manoeuvres, Non-coplanar transfer; Rendezvous missions, interplanetary trajectories, gravity assist trajectories; Orbit perturbations. **Rocket Vehicle Dynamics:** Basic functions and features of rockets and missiles; Tsiolkovsky rocket equation; Launch vehicle ascent trajectories and its different phases, effect of aerodynamic drag and gravity on ascent mission performance, vertical, inclined and gravity turn trajectories; Static and dynamic stability of rockets, rocket thrust vector control methods; Concept of multi-staging, series and parallel staging configurations, optimal staging solutions; Re-entry vehicles and missions, aerobraking. **Attitude Dynamics and Control:** Euler's equations for rotational dynamics; Torque-free motion of asymmetric and axisymmetric rigid bodies; Spinning and non-spinning spacecraft, dual spin spacecraft, effect of energy dissipation on stability of rotational motion, nature of attitude response to atmospheric disturbances; Overview of actuation mechanisms for attitude control, gyroscopic motion, stabilization through gravity gradient, attitude sensors, design of control of three-axis stabilized

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	spacecraft in orbit using reaction wheels, thrusters, magnets, single and double gimbaled control moment gyros, Yo-Yo mechanism. TEXT BOOKS:- 1. "Orbital Mechanics for Engineering Students", H.D. Curtis, Butterworth-Heinemann 2. "Elements of Space Technology", R.D. Meyer, Academic Press REFERENCE BOOKS:- 1. "Orbital Mechanics", V.A. Chobotov, AIAA Education Series 2. "Fundamentals of Astrodynamics", R.R. Bate, D.D. Mueller & J.E. White, Dover Books 3. "Spaceflight Dynamics", W.E. Wiesel, Aphelion Press 4. "Fundamentals of Astrodynamics and Applications", D.A. Vallado, J. Wertz, Microcosm Press 5. "Rocket and Spacecraft Propulsion", M.J.L. Turner, Springer
6ANU5	**Mechanics of Composites**
	Fundamentals of Composite materials: Definition, matrix & fibres, various types of matrix materials and their properties, properties of various type of fibres like glass, Kevlar, carbon and graphite; Polymers, properties of polymers like epoxy, polyester and phenolic; Applications of composites with emphasis on aerospace industry. **Manufacturing of Composites:** Hand lay-up technique; Autoclave moulding; Pressure bag and vacuum bag moulding; Pultrusion; Resin-transfer moulding; Injection moulding; Bulk and sheet moulding compound methods; Prepregs. **Elastic Behaviour of Composite Lamina-Micromechanics:** Volume fraction, weight fraction, density of composites; Micromechanics and Macromechanics approach; Longitudinal elastic properties, transverse elastic properties, in-plane shear modulus, Poisson's ratio, Halpin-Tsai equations. **Elastic behaviour of Composite Lamina-Macromechanics:** Stress-Strain relations, general anisotropic materials, orthotropic material, transversely isotropic material, isotropic material; Stress-strain relations for a thin lamina.

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	Analysis of multidirectional Laminates: Laminate orientation code, symmetric and balanced laminate; Introduction to cross-ply, angle-ply and quasi isotropic laminates; Classical laminate theory, strain-displacement relationship, stress-strain relations, force and moment resultants, in-plane and flexural laminate stiffness; Asymmetric laminate and coupling effect; Stress analysis of cross-ply symmetric laminate under in-plane and flexural loading. **Special Types of Composites:** Short fibre composites; Sandwich structure composites; Honeycomb structure. **Mechanical Testing of Composites:** Tensile testing; Compressive testing; Intra-laminar shear testing; Fracture testing; Impact testing; Fatigue testing. **Failure and Maintenance of Composites:** Failure types in laminates; Damage to laminate structures; Inspection methodology, quality control. TEXT BOOKS:- 1. "Analysis and Performance of Fiber Composites", B.D. Agarwal & L.J. Broutman, John Wiley & Sons 2. "Engineering Mechanics of Composite Materials", I.M. Daniel & O. Ishaai, Oxford University Press REFERENCE BOOKS:- 1. "Mechanics and Analysis of Composite Materials", V.V. Vasiliev & E.V. Morozov, Elsevier Science Ltd. 2. "Mechanics of Composite Materials", R.M. Jones, Taylor and Francis 3. "Principles of Composite Material Mechanics", Ronald F. Gibson, CRC Press 4. "Mechanics of Composite Materials", Autar K. Kaw, Taylor and Francis 5. "Composite Material: Science and Engineering", K.K. Chawla, Springer-Verlag New York Inc.
6ANU6.1	**Unmanned Aerial Vehicles**
	Introduction: History, classification and applications of UAVs; Unmanned Aircraft System (UAS), UAS composition, societal impact, future prospects; Regulations and safety considerations. **Characteristics of UAV Types:** Long-range, long-endurance, MUAV types, MAV and NAV types, UCAV, Novel hybrid aircraft configurations.

	UAV Propulsion: Internal combustion engines; Turbine engines; Electrical systems. **Aerodynamics:** Low Reynolds number effects; Lift-induced drag, parasite drag; Rotary wing aerodynamics; Response to air turbulence; Dynamic stall. **Control and Stability:** Flight control of HTOL aircraft, helicopters, convertible rotor aircraft; Autopilot systems & ground control station; Sensors used in UAVs; On-board flight control **Introduction to Design and Selection of UAV:** Conceptual design, preliminary design, detailed design, selection of UAV for particular requirement. **Aspects of Airframe Design:** Airframe configuration, scale effects, packaging density; Aerodynamic design; Strength, stiffness and reliability requirements; Flight and gust envelopes including manoeuvre loads; Selection of power plants; Design for stealth. **Payload Types:** Non-dispensable and dispensable payloads, sensing/surveillance, weaponized, delivery. **Communications:** Communication media, radio communication, mid-air collision avoidance system, communication data range and bandwidth usage, antenna types, telemetry. **Navigation:** NAVSTAR-GPS, TACAN, LORAN-C, inertial navigation, radio tracking. TEXTBOOKS:- 1. "Unmanned Aircraft Systems: UAVS Design, Development and Deployment", Reg Austin, Wiley 2. "Introduction to Unmanned Aircraft Systems", D.M. Marshall, R.K. Barnhart, E. Shappee & M.T. Most, CRC Press REFERENCE BOOKS:- 1. "Small Unmanned Aircraft: Theory and Practice", R.W. Beard & T.W. McLain, Princeton University Press 2. "Unmanned Aircraft Systems", E. Atkins, A. Ollero & A. Tsourdos, John Wiley & Sons 3. "Introduction to UAV Systems", P. Fahlstrom & T. Gleason, Wiley 4. "Theory, Design, and Applications of Unmanned Aerial Vehicles", A.R. Jha, CRC Press

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	5. "Unmanned Aviation Systems: The Definitive Guide", M. Leasure & M.S. Nolan, eAcademicBooks LLC
6ANU6.2	**Experimental Fluid Mechanics**
	Basic Concepts: Objective and importance of experimental studies; Properties of fluids, measuring instruments; Principle of similitude; Components of measuring systems. **Experimental Setup:** Low speed wind tunnel, high speed wind tunnel, special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions; Water tunnel, towing tank; Effect of Reynolds number and freestream turbulence; Instrumentation and calibration. **Flow Visualization Techniques:** Smoke tunnel; Surface oil flow, tuft visualization; Dye injection techniques; Hele-Shaw apparatus; Interferometer; Shadowgraph; Schlieren system. **Pressure Measurement:** Pitot static tube; Manometer; Pressure transducers; Pressure Sensitive Paints. **Velocity Measurement:** Hot-wire and hot-film anemometry; Laser Doppler Velocimetry; Particle Image Velocimetry. **Temperature Measurement:** Thermometer; Thermocouple; Thermistor. **Force Measurement:** Different types of balances, internal and external balances; Balance calibration. **Data Acquisition and Signal Conditioning:** Data acquisition principle; Static and dynamic response of measuring systems; Analogue to digital conversion; Multiplexing; Types of signals; Fourier Analysis; Analysis of periodic signals. **Uncertainty Analysis:** Types of measurement error, error estimation; Error analysis and uncertainty propagation. TEXT BOOKS:- 1. "Instrumentation, Measurements, and Experiments in Fluids", E. Rathakrishnan, CRC Press 2. "Fluid Mechanics Measurements", R. Goldstein, CRC Press REFERENCE BOOKS:- 1. "Measurement in Fluid Mechanics", S. Tavoularis, Cambridge University Press

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	2. "Springer Handbook of Experimental Fluid Mechanics", C. Tropea, A. Yarin & J.F. Foss, Springer 3. "Introduction to Instrumentation and Measurements", R.B. Northrop, CRC Press
6ANU6.3	**Fatigue and Fracture**
	Introduction: Kinds of failure, brittle and ductile fracture; Modes of fracture failure; Brief introduction of parameters to measure crack potency; Importance of fracture mechanics in aerospace structures. **Fatigue of Structures:** S-N curves, endurance limits, effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams; Neuber's stress concentration factors, plastic stress concentration factors; Crack initiation, crack growth, final fracture, factors affecting fatigue crack propagation, dislocations, fatigue fracture surfaces. **Statistical Aspects of Fatigue:** Low cycle and high cycle fatigue, cyclic strain hardening and softening; Coffin-Manson's relation; Analysis of load histories, cycle counting techniques, cumulative damage. **Energy Release Rate:** Griffith's analysis; Energy release rate formulation; Crack resistance, crack growth, R-curve; Critical energy release rate for plane stress and plane strain. **Stress Intensity Factor:** LEFM, EPFM; Stress and displacement fields in isotropic elastic materials; Stress intensity factor formulation; Field equations. **Elastic Deformation at the Crack Tip:** Plastic zone for plane stress and plane strain; effective crack length formulation using Irwin and Dugdale approaches; Introduction of J-Integral; Crack Tip Opening Displacement (CTOD), Equivalence between CTOD and J-integral. **Crack Detection Test:** NDT methods; Experimental determination of GIC, KIC and CTOD. TEXT BOOKS:- 1. "Elements of Fracture Mechanics", Prashant Kumar, McGraw Hill Education 2. "Fracture Mechanics: Fundamentals and Applications", T.L. Anderson, CRC Press REFERENCE BOOKS:-

	1. "Fatigue and Fracture: Understanding the Basics", F. C. Campbell, ASM International 2. "Fracture Mechanics: An Introduction", E.E. Gdouto, Springer 3. "Fundamentals of Fracture Mechanics", Tribikram Kundu, CRC Press 4. "Introduction to Fracture Mechanics", Kare Hellan, McGraw-Hill Inc. 5. "Elementary Engineering Fracture Mechanics", David Broek, Springer
6ANU6.4	**Renewable Energy Systems** (common with 6MEU6.1)
	Introduction: Renewable and non-renewable energies, significance of renewable energy; Global and national scenarios, form and characteristics of renewable energy sources. **Solar Energy:** Solar radiation, its measurements and prediction; Solar thermal collectors, flat plate collectors, concentrating collectors; Solar heating of buildings, solar still, solar water heaters, solar driers; Conversion of heat energy into mechanical energy, solar thermal power generation systems; Solar photovoltaic cell and its applications. **Wind Energy:** Atmospheric circulations, classification, factors influencing wind; Wind shear, turbulence, wind speed monitoring; Different types of wind turbines and their applications. **Ocean Energy:** Ocean energy resources, ocean energy routes; Principles of ocean thermal energy conversion systems, ocean thermal power plants; Principles of ocean wave energy conversion and tidal energy conversion. **Other Sources:** Nuclear fission and fusion; Geothermal energy, its origin, types of geothermal energy sites, site selection, geothermal power plants; Magneto-hydro-dynamic (MHD) energy conversion; Biomass resources and their classification, chemical constituents and physicochemical characteristics of biomass, biomass conversion processes. **Fuel Cells:** Thermodynamics and electrochemical principles; Basic design, types, applications. **Hydrogen Energy:** Economics of hydrogen; Production methods. TEXT BOOKS:- 1. "Renewable Energy: Power for a Sustainable Future", Stephen Peake, Oxford University Press 2. "Renewable Energy Systems", D.M. Buchla, T.E. Kissell & T.L. Floyd, Pearson Education

	REFERENCE BOOKS:- 1. "Renewable Energy Resources", J. Twidell & T. Weir, Routledge 2. "Non-conventional Energy Sources", G.D. Rai, Khanna Publications 3. "Non-Conventional Energy Resources", B.H. Khan, McGraw Hill Education India Private Limited 4. "Renewable Energy Engineering and Technology: Principles and Practice", V. V. N. Kishore, Routledge 5. "Non-Conventional Sources of Energy", Ankur Mathur, Laxmi Publications
6ANU7	**Aerospace Propulsion Lab**
	• Study of an aircraft piston engine (includes study of assembly of subsystems, various components, their functions and operating principles) • Study of an aircraft jet engine (includes study of assembly of subsystems, various components, their functions and operating principles) • Scrutiny of the constructional details of combustion chamber • Analysis of performance of a propeller • Characterization of intake • Experiment on axial compressor (flow fan) test rig • Study of an aircraft computerized gas turbine • Ignition studies of solid and liquid propellants • Understanding operation of a ramjet engine • Measurement of nozzle flow • Cascade testing of a model of axial compressor and turbine blade row • Flame stabilization in continuous combustion unit • Burning rate measurement of solid propellants in a strand burner • Description of constructional details of afterburning system
6ANU8	**Aeromodelling Design and Fabrication**
	• Design and fabrication of fixed-wing gliders • Comparison of properties of thermocole, balsa wood, Styrofoam, composites for aeromodel fabrication • Detailed design of fixed-wing powered aeromodels

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	• Design, fabrication and testing of different components • Aerodynamic and structural design • Use of flight simulator to practise flying aeromodels • Concepts used in unconventional UAVs such as rotary wing models and ornithopters
6ANU9	**Advanced Programming using MATLAB**
	• Basics of MATLAB computer programming • Use of formulae and inbuilt functions • MATLAB scripts and functions (m-files) • Loops and nested loops • Array, vector and matrices • Plotting functions and vector plots • Solving differential equations using MATLAB • Reading and writing data, file handling • Using MATLAB toolboxes • MATLAB graphic functions TEXT BOOKS:- 1. "Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers", R. Pratap, Oxford 2. "MATLAB for Beginners: A Gentle Approach", P.I. Kattan, P.I. Kattan REFERENCE BOOKS:- 1. "MATLAB For Dummies", J. Sizemore, John Wiley & Sons 2. "Modeling and Simulation using MATLAB – Simulink", S. Jain, Wiley 3. "MATLAB Programming for Engineers", S.J. Chapman, Cengage 4. "Essential MATLAB for Engineers and Scientists", B. Hahn, D.T. Valentine, Academic Press 5. "MATLAB: An Introduction with Applications", A. Gilet, Wiley

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6ANU10	**Mechatronics Lab**
	• Introduction to the concept of Mechatronics and its applications • Study of different types of sensors and transducers • Introduction to Arduino IDE and its basic commands • Introduction to programming in LabVIEW • Use of LabVIEW for data acquisition • Variation of blink rate and brightness of LEDs • Using servo motor as an actuator to move to specified position • Speed control of stepper motor • Use of relay as conditional switch • Use of strain guage sensor for measuring loads • Temperature measurement using thermocouple • Measurement of pressure using data acquisition system • Introduction to Simulink
6ANU11	**Business Communication Skills**
	Introduction: Process of communication, importance of communication in business; Differences between technical and general communication; Barriers to communication and measures to overcome them. **Language for Communication:** Language and communication; Essentials of good style, expressions and words to be avoided, grammar and usage. **Listening Skills:** Importance of Listening, barriers to listening, strategies for effective listening, listening in a business context. **Oratory Skills:** Structure of different types of business speeches, public speaking, voice modulation; Quotations by prominent business personalities; Practice of appreciation, motivation, criticism. **Internal Business Communication:** Guidelines for attending meetings, common mistakes made at meetings; Writing memos, circulars and notices, important guidelines.

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	External Business Communication: Writing business letters, importance of business letters, difference between personal and business letters; Types of business letters, structure and format of business letters and important their features such as style, effectiveness, promptness; Communication with media through news releases and advertisements. **E-mail Writing:** Communication through e-mail, e-mail etiquette; Overcoming problems in e-mail communication. **Body Language:** Importance of body language; Appropriate body postures in standing or sitting position, body movements during presentations and speeches, gestures, facial expressions, eye movements in response to different situations; Video samples. **Presentation Skills:** Importance of giving presentations, presentation skills, use of visual aids such as handouts, transparencies and presentation software, features of a good presentation; Video conferencing. **Technical Report Writing:** Types of reports and different formats, purpose of report writing; Structure of report; Features of effective writing such as clarity, brevity, appropriate tone, balance etc.; Synopsis and thesis writing. **Employment Communication:** Preparing resume, contents of good resume, guidelines for writing resume, different types of resumes; Writing cover letter; Group discussion skills; Interview skills, manners and etiquettes to be maintained during an interview, sample questions commonly asked during interview. TEXT BOOKS:- 1. "Business Communication: Process and Product", M.E. Guffey & D. Loewy, Cengage Learning 2. "Business Communication: Making Connections in a Digital World", R. Lesikar, M.E. Flatley & K. Rentz, McGraw-Hill College REFERENCE BOOKS:- 1. "Business Communication: Developing Leaders for a Networked World", P. Cardon, McGraw-Hill Education 2. "Basic Communication Skills for Technology", A.J. Rutherfoord, Pearson 3. "Essentials of Business Communication", R. Pal & J.S. Korlhalli - Sultan Chand & Sons 4. "Business Communication: Skills, Concepts, and Applications", P.D. Chaturvedi & M. Chaturvedi, Pearson India

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	5. "Contemporary Business Communication", S. Ober, Cengage Learning
6ANUDC	**Discipline & Extra-Curricular Activities**
	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 7th Semester

Codes	Syllabus
7ANU1	**Aerospace Propulsion – II**
	Propeller Theory: Momentum theory, blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters. **Fundamentals of Combustion:** Thermochemistry, stoichiometric ratio and mixture ratio, energy release during combustion, heat of formation, heat of combustion, stoichiometric reaction; Adiabatic flame temperature, flammability and stability limits; Premixed and diffusion flames; Chemical equilibrium, chemical kinetics, reacting flow, frozen flow. **Gas Turbine Combustors:** Types of aviation fuels; Classification of combustion chambers, important factors affecting combustion chamber design; Combustion process; Combustion chamber performance; Ignition and engine starting; Flame tube cooling; Flame stabilization; Afterburners, supercharging. **Ramjet Propulsion:** Operating principle of ramjet propulsion, types of ram propulsion; Efficiencies of different components; Critical, subcritical and supercritical modes of combustion; Need for supersonic combustion for hypersonic propulsion, salient features of scramjet engine and its applications for hypersonic vehicles, problems associated with supersonic combustion. **Rocket Propulsion:** Brief history and principle of rocket; Rocket equation; Classification of rockets, mass ratio of rocket; Solid propellant rockets, estimation of solid propellant adiabatic flame temperature; Salient features of liquid propellant rockets, selection of liquid propellants, thrust control in liquid rockets, cooling in liquid rockets; Hybrid rocket propulsion; Rocket nozzles, conical nozzle and contour nozzle, under and over expanded nozzles, flow separation in nozzles, unconventional nozzles; Nozzle performance, nozzle area ratio, mass flow rate, characteristic velocity; Thrust coefficient, performance parameters; Staging and clustering. **Advanced Propulsion Techniques:** Arc jet, Resisto jet; Hall effect thrusters; Electric rocket propulsion; Ion propulsion techniques; Nuclear rocket; Solar sail; Preliminary Concepts in nozzleless propulsion; Thrust reverser; Stealth technology. TEXT BOOKS:- 1. "Rocket Propulsion Elements", G.P. Sutton & O. Biblarz, John Wiley & Sons

	2. "Theory of Aerospace Propulsion", P.M. Sforza, Butterworth-Heinemann REFERENCE BOOKS:- 1. "Aerospace Propulsion System", T.A. Ward, Wiley 2. "Aerospace Propulsion", T.W. Lee, Wiley-Blackwell 3. "Aircraft Engines and Gas Turbines", J.L. Kerrebrock, The MIT Press 4. "Aircraft Propulsion and Gas Turbine Engines", A.F. El-Sayed, CRC Press 5. "Understanding Aerospace Chemical Propulsion", H.S. Mukunda, I.K. International Publishing House Pvt. Ltd.
7ANU2	**Aircraft Design**
	Aircraft Design Fundamentals: Introduction to design, engineering design, feasibility analysis, review, evaluation, and feedback; Conceptual system design, preliminary system design, detail system design; Aircraft design requirements and specifications, airworthiness, aerodynamic and structural design considerations; UAV design. **Aircraft Conceptual Design:** Aircraft configuration alternatives, aircraft classification and design constraints; Configuration selection process and trade-off analysis; Material selection; Conceptual design optimization. **Preliminary Design:** Maximum Take-Off Weight Estimation; Estimation of cruise and manoeuvring loads; Load factor, v-n diagram; Wing loading, wing area; Engine sizing. **Wing Design:** Factors influencing selection of airfoil and planform; Spanwise load distribution, Stalling, take-off and landing considerations; Bending moment and shear force; Selection of wing vertical location, airfoil section, wing incidence, aspect ratio, taper ratio, sweep angle, twist angle, dihedral angle, high-lift device; Estimation of wing drag. **Tail Design:** Aircraft trim requirements; Tail configuration, canard or aft tail; Optimum tail arm; horizontal tail parameters; Vertical tail design. **Fuselage Design:** Fuselage configuration design and internal arrangement; Cockpit design; Passenger cabin design; Cargo section design; Other fuselage internal segments; Optimum length-to-diameter ratio; Lofting.

	Propulsion System Design: Functional analysis and design requirements; Selection of type of engine, number of engines, engine location; Engine installation; Propeller sizing; Engine performance. **Landing Gear Design:** Functional analysis and design requirements; Selection of landing gear configuration, possible retraction mechanism into fuselage or wing; Landing Gear position according to aircraft centre of gravity; Absorption of landing loads. **Design of Control Surfaces:** Aileron Design, Elevator Design, Rudder Design. **Weight Calculation:** Estimation of weight of major components, Aircraft weight distribution; Aircraft centre of gravity calculation, centre of gravity range; Aircraft mass moment of inertia. **Advanced Design Concepts:** Supersonic aircraft design; Very large aircraft; Morphing aircraft; Supercritical wing; Relaxed stability; Flying wing, tailless, lifting fuselage, and blended wing-body designs; Special considerations such as stealth, maintainability etc. **Complete Design Problem:** Design of airframe for given specifications with constraints; Prediction of performance, stability and control, range-payload diagram, v-n diagram, noise and emission levels, life cycle cost; Reviewing selection of engines from all considerations; Freezing the design; Preparation of preliminary drawings including 3 views and layout. TEXT BOOKS:- 1. "Aircraft Design: A Conceptual Approach", D.P. Raymer, AIAA Education Series 2. "Aircraft Design: A Systems Engineering Approach", M. H. Sadraey, Wiley-Blackwell REFERENCE BOOKS:- 1. "Aircraft Design", A.K. Kundu, Cambridge University Press 2. "Introduction to Aircraft Design", J.P. Fielding, Cambridge India 3. "General Aviation Aircraft Design: Applied Methods and Procedures", S. Gudmundsson, Butterworth-Heinemann 4. "Design of Aircraft", T.C. Corke, Pearson

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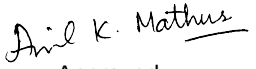
	5. "Advanced Aircraft Design: Conceptual Design, Analysis and Optimization of Subsonic Civil Airplanes", E. Torenbeek, Wiley-Blackwell
7ANU3	**Introduction to Computational Fluid Dynamics**
	Introduction: Importance and applications of CFD in diverse fields; Different types of partial differential equations — hyperbolic, parabolic, elliptic and mixed types; Fundamental concept of CFD. **Governing equations:** Continuity, momentum and energy equations in conservative and non-conservative forms; Governing equations in boundary layers and inviscid flows; Initial and boundary conditions. **Discretization:** Concept and need of discretization of differential equations; Different discretization techniques — finite difference, finite element and finite volume methods and their comparison; Fundamentals of FDM, forward, backward and central difference, ADI scheme, applications to simple problems such as transient one-dimensional and two-dimensional conduction; Stability criterion, errors, consistency, optimum step size. **Grid generation:** Types of grid; Structured, unstructured and hybrid mesh in 2d & 3d, their relative merits and regions of application; Coordinate transformation; Elliptic grid generation; Grid independence test; Adaptive grids, modern developments in grid generation. **Calculation of flow field:** Methods of solution, simple 1d computations using different methods; Convergence criterion; Implicit and explicit algorithms; Pressure and velocity corrections; Vorticity-streamfunction method; Solution of turbulent flows and turbulence modelling. TEXT BOOKS:- 1. "Computational Fluid Dynamics – The Basics with Applications", J. D. Anderson Jr., McGraw-Hill 2. "Computational Fluid Flow and Heat Transfer", K. Muralidhar & T. Sundarajan, Narosa Publishing House REFERENCE BOOKS:- 1. "Numerical Computation of Internal and External Flows", C. Hirsch, Butterworth-Heinemann 2. "Fundamentals of Engineering Numerical Analysis", P. Moin, Cambridge University Press

	3. "Numerical Methods for Engineering Application", J. H. Ferziger, Wiley 4. "Computational Methods for Fluid Dynamics", J. H. Ferziger & M. Peric, Springer 5. "Computational Fluid Dynamics", T.J. Chung, Cambridge University Press
7ANU4	**Finite Element Method**
	Introduction and Review of Mathematics: Introduction to FEM and its applications; Advantages of FEM, comparison with other methods such as FDM and FVM; Review of matrix algebra, Gauss elimination method, banded symmetric matrix and bandwidth. **Discretization:** Geometrical approximations, Element shapes and behaviour, Choice of element types, size and number of elements, Location of nodes; p and h method of mesh refinement; Shape functions and their properties; Assembly and boundary conditions. **Finite Element Formulation from Governing Differential Equations:** General field problems, discrete and continuous models; Method of weighted residuals; Galerkin's method and other methods; Introduction to variational formulation (Ritz technique); Convergence of solution, compatibility. **One-Dimensional Finite Element Analysis:** One-dimensional second order equation, derivation of shape functions, Stiffness matrix and force vectors, assembly of elemental matrices, Derivation of finite elements equations using potential energy approach, 1-D bar element; longitudinal vibration and mode shapes, fourth order beam equation, transverse deflections and natural frequencies, solution of problems from fluid mechanics and heat transfer. **Two-Dimensional Finite Element Analysis:** Finite element formulation using three node triangular (CST) element and four node rectangular element, Plane stress and Plain strain problems, node numbering and connectivity; Application to thermal problems. **Introduction to Numerical Integration:** Numerical integration using Gauss Quadrature Formula. TEXT BOOKS:- 1. "Fundamental of Finite Element Analysis", D.V. Hutton, McGraw Hill Education 2. "Text Book of Finite Element Analysis", P. Seshu, Prentice Hall India

	REFERENCE BOOKS:- 1. "An Introduction to the Finite Element Method", J.N. Reddy, McGraw-Hill 2. "Finite Element Procedure in Engineering Analysis", K.J. Bathe, Prentice Hall India 3. "Introduction to Finite Elements in Engineering", T.R. Chandrupatla & A.D. Belegundu, Prentice Hall of India 4. "Applied Finite Element Analysis", L.J. Segerlind, John Wiley & Sons 5. "Concepts and Applications of Finite Element Analysis", R.D. Cook, D.S. Malcus, M.E. Plesha & R.J. Witt, John Wiley & Sons
7ANU5	**Automatic Control Systems**
	Introduction: Open loop and closed loop control systems, series and parallel system; Feedback characteristics of control systems; Mathematical models of physical systems; Control systems and components. **Feedback Control System**: Transfer function of linear systems; Impulse response of linear Systems; Block diagrams of feedback control systems, reduction of block diagrams, signal flow graphs, output to input ratios. **Analysis of Feedback Control Systems**: Time response analysis, effects of derivative and integral control; Different types of test inputs; Steady state response of feedback control system, steady state error; Frequency response; Correlation between frequency domain and time domain specifications; Bode plot analysis. **System Stability:** Concept of stability and algebraic criteria; Routh-Hurwitz criterion; Root locus technique; Nyquist stability criterion. **State Variable Analysis and Design:** Introduction to state variables; Compensator design; Controller design. **Longitudinal Auto-Pilots:** Brief description through block diagrams and root locus of displacement; Pitch orientation control system, acceleration control system; Fly-by-wire control system; Instrument Landing System. TEXT BOOKS:- 1. "Modern Control Engineering", K. Ogata, PHI learning 2. "Automatic Control Systems", B,C. Kuo & F. Golnaraghi, Wiley REFERENCE BOOKS:-



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	1. "Aircraft Flight Dynamics and Control", W. Durham, Wiley-Blackwell 2. "Control System Design: An Introduction to State-Space Methods", B. Friedland, Dover Publications Inc. 3. "Automatic Control of Aircraft and Missiles", J.H. Blackelock, John Wiley & Sons 4. "Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems", B.L. Stevens, F.L. Lewis & E.N. Johnson, John Wiley & Sons 5. "Advanced Control of Aircraft, Spacecraft and Rockets", Ashish Tewari, Wiley-Blackwell
7ANU6.1	**Non-Destructive Testing**
	Introduction to NDT: Fundamentals of non-destructive testing and evaluation, physical characteristics of materials and their applications in NDT, advantages and limitations of NDT; Visual inspection techniques. **Liquid Penetrant Testing:** Basic principle; types and properties of liquid penetrants, methods of application; Developer application and inspection, interpretation of results. **Magnetic Particle Testing:** Basic theory of magnetism; Magnetization methods; Field indicators, particle application, inspection. **Eddy Current Testing:** Basic principle, Faraday's law, inductance, Lenz's law, self and mutual inductance, impedance plane; Generation of eddy currents, properties of eddy currents, eddy current sensing elements, inspection system and probes, eddy current instrumentation; System calibration; Applications and limitations. **Ultrasonic Testing:** Basics of ultrasonic waves; Ultrasonic equipment; Test method, variables affecting an ultrasound test; Distance and Area calibration; Weld inspection by UT. **Radiography:** X-rays and their properties; X-ray generation, absorption and atomic scattering; Image formation, image quality; Digital Radiography, neutron radiography; Image interpretation; Radiation Shielding; Radiography applications, limitations and safety. **Special Techniques:** Acoustic Emission testing; Holography; Thermography; Magnetic Resonance Imaging; In-situ metallography.

	Industrial Applications of NDT: Span of NDT activities in railways, nuclear and chemical industries, aircraft and aerospace industries, automotive industries, offshore gas and petroleum projects, coal mining industry; NDT of pressure vessels, castings, welded constructions. TEXT BOOKS:- 1. "Non-Destructive Testing", Louis Cartz, ASM International 2. "Non-Destructive Test and Evaluation of Materials", J. Prasad & C.G.K. Nair, McGraw Hill Education REFERENCE BOOKS:- 1. "Non-Destructive Testing Techniques", Ravi Prakash, New Age International Publishers 2. "Introduction to Non-Destructive Testing: A Training Guide", P.E. Mix, Wiley 3. "Aeronautical Applications of Non-Destructive Testing", Abbas Fahr, DEStech Publications 4. "Practical Non-Destructive Testing", B. Raj, T. Jayakumar & M. Thavasimuthu, Narosa Publishing House 5. "Non-Destructive Testing", B. Hull & V. John, Springer-Verlag New York Inc.
7ANU6.2	**Experimental Stress Analysis**
	Measurements: Principles of measurements; Accuracy, sensitivity and range of measurements. **Extensometers and Displacement Sensors:** Mechanical, optical, acoustical and electrical extensometers and their uses, advantages and disadvantages; Capacitance gauges; Laser displacement sensors. **Electrical Resistance Strain Gauges:** Principle of operation; Types of strain gauges; Materials for strain gauges, strain gauge adhesives; Gauge sensitivity and gauge factor; Calibration and temperature compensation; Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements; Load cells; Data acquisition. **Photoelasticity**: Two-dimensional photoelasticity, photoelastic materials; Photoelastic effects; Stress optic law; Transmission photoelasticity; Plane and circular polariscopes, interpretation of fringe pattern; Calibration of photoelastic materials; Introduction to three-dimensional photoelasticity.

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	Brittle Coating and Moire Techniques: Relation between stresses in coating and specimen, use of failure theories in brittle coating; Moire method of strain analysis. **Non-Destructive Testing:** Fundamentals of NDT; Acoustic Emission Technique; Radiography; Thermography; Ultrasonic testing; Eddy Current testing; Fluorescent penetrant testing. TEXT BOOKS:- 1. "Experimental Stress Analysis", J.W. Dally & W.F. Riley, McGraw Hill Inc. 2. "Elements of Experimental Stress Analysis", A. W. Hendry, Elsevier REFERENCE BOOKS:- 1. "Experimental Stress Analysis", U.C. Jindal, Pearson India 2. "Experimental Stress Analysis: Principles and Methods", G.S. Holister, Cambridge University Press 3. "Experimental Stress Analysis", Sadhu Singh, Khanna Publishers 4. "Handbook of Experimental Stress Analysis", Miklos Hetenyi, Forgotten Books 5. "Modern Experimental Stress Analysis", J.F. Doyle, Wiley India Private Limited
7ANU6.3	**Artificial Intelligence**
	Introduction: Artificial intelligence and related fields, brief history of AI; Applications of artificial intelligence; Definition and importance of Knowledge and Learning. **Problem Solving:** Problem definition, problem as a state space search, problem formulation; Problem types, well-defined problems, constraint satisfaction problem, game playing, production systems. **Search Techniques:** Uninformed search techniques: depth first search, breadth first search, depth limit search, search strategy comparison; Informed search techniques: hill climbing, best first search, greedy search, A* search; Adversarial search techniques: minimax procedure, alpha beta procedure. **Machine Learning:** Concepts of learning; Learning from examples; Explanation based learning; Learning by analogy; Learning by simulating evolution; Learning by training neural nets; Learning by training perception.

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	Knowledge Representation and Reasoning: Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; Predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications. **Decision-Making**: Basics of Utility Theory; Decision Theory, sequential decision problems; Elementary Game Theory. **Fuzzy Set Theory:** Introduction to fuzzy set with properties; Fuzzy relations; Fuzzy arithmetic; Fuzzy logic; Fuzzy control. TEXT BOOKS:- 1. "Artificial Intelligence: A Modern Approach", S.J. Russell & P. Norvig, Pearson Education India 2. "A First Course in Artificial Intelligence", Deepak Khemani, McGraw Hill Education REFERENCE BOOKS:- 1. "Artificial Intelligence", R. Knight, McGraw-Hill 2. "Neural Networks: A Comprehensive Foundation", S. Haykin, Pearson Education 3. "Artificial Intelligence", P.H. Winston, Pearson Education 4. "Artificial Neural Networks", B. Yegnanarayana, Prentice Hall of India 5. "Artificial Intelligence", E. Rich, K. Knight & S.B. Nair, McGraw Hill Education
7ANU6.4	**Fuel Cells and Hybrid Engine Technology** (common with 7MEU6.2)
	Introduction: Rational behind fuel cell development, basic principle of fuel cell, operation of fuel cell, efficiency of fuel cell; Co-generation of heat and power; Important reactions such as hydrogen oxidation, methanol oxidation etc. **Types of Fuel Cell:** DMFC (Direct Methanol Fuel Cell); PAFC (Phosphoric Acid Fuel Cells); MCFC (Molten Carbonate Fuel Cells); SOFC (Solid Oxide Fuel Cells). **Fuel Processing:** Purpose, producing hydrogen from alcohol, producing hydrogen from hydrocarbon, hydrogen from other sources; Gas cleanup, reformer system, hydrogen storage system engineering; Fuel cell engineering, vehicle cell design, stack engineering, fuel processing, system application; Stationary power, propulsion of vehicle, portable application.

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	Electric Vehicle: Introduction, working; Electric car motors, electric car batteries, charging system of electric car, magna charge system; Conversion system for transmission. **Hybrid Vehicle:** Introduction, working; Power split devices; Hybrid car performance, gasoline hybrid structure; Gasoline vs. electric power; Transmission components of hybrid vehicle; Different types of hybrid vehicle; Advantage and limitations of hybrid vehicles. **Solar Vehicles:** Introduction and working, photovoltaic cell, solar cell; Energy losses in solar cell; Solar powering house; Solar cost, anatomy of solar cells. TEXT BOOKS:- 1. "Electric and Hybrid Vehicles: Design Fundamentals", Iqbal Husain, CRC press 2. "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles", M. Ehsani, Y. Gao, S. Longo & K. Ebrahimi, CRC Press REFERENCE BOOKS:- 1. "Fuel Cell Technology", N. Sammes, Springer 2. "Microbial Fuel Cell", B.E. Logan , Wiley 3. "Principle of Fuel Cell", Xianguo Li, CRC Press 4. "Hydrogen Fuel Cells for Road Vehicles", P. Corbo, F. Migliardini & O. Veneri, Springer 5. "Electrical Vehicle Technology", James Laraminie, Wiley
7ANU7	**CFD Lab**
	• Introduction to ANSYS Fluent, its features and different options • Generation of structured and unstructured mesh over simple objects • Boundary layer resolution and grid independence test • Flow over flat plate and use of transition models • Inviscid and viscous flow over circular cylinder at different Reynolds number • Laminar and turbulent flow in a pipe • Flow over airfoil at high Reynolds number and use of different turbulence models

	• Supersonic flow past wedge and cone • Transonic flow over subsonic and supercritical airfoils • Flow over finite wing and effect of aspect ratio and taper ratio • Flow in nozzles and diffusers • Writing codes in C/ C++/ MATLAB for simple flow fields REFERENCE BOOKS:- 1. "ANSYS Fluent Tutorial Guide", Sylvain Serra 2. "ANSYS FLUENT 14.0 Simulation Analysis and Design Optimization", S.B. Cheng & L.M.G. Bian, Machinery Industry Press 3. "FLUENT Learning Modules", S. Weidner, Cornell University Confluence (https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules) 4. "ANSYS Workbench 14.0 for Engineers and Designers", Sham Tickoo, Dreamtech Press
7ANU8	**Aircraft Design Lab**
	• Conceptual design based on preliminary mission requirements • Survey of existing vehicular configurations (in similar category) • Lofting (preliminary layout sketches) • Preliminary weight estimation • Optimization of wing loading and thrust loading • Selection of engine • Selection of wing parameters • Selection of fuselage parameters and internal layout • Location of engines and landing gear • Design of tail areas and control surfaces • Revised three-view drawing • Estimation of weights of various components • Calculation of centre of gravity and its shift

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	• Estimation of aerodynamic characteristics and performance evaluation • Estimation of spanwise load distributions on wing and tail • V-n diagram for the design study • Estimation of gust and manoeuvrability envelopes • Internal design of wing and fuselage considering buckling loads and margin of safety • Estimation of cost and airworthiness of airplane, trade-off studies TEXT BOOK:- 1. "Aircraft Design: A Conceptual Approach", D.P. Raymer, AIAA Educational Series REFERENCE BOOKS:- 1. "Fundamentals of Aircraft Design", L.M. Nicolai, METS Inc. 2. "Synthesis of Subsonic Airplane Design", E. Torenbeek, Springer 3. "Aircraft Conceptual Design Synthesis", D. Howe, Wiley 4. "Aircraft Design Projects: For Engineering Students", L.R. Jenkinson & J.F. Marchman, AIAA Education Series 5. "Civil Jet Aircraft Design", L.R. Jenkinson, P. Simpkin & D. Rhodes, AIAA Education Series
7ANU9	**FEM Lab**
	• Introduction of GUI of the software ANSYS • Analysis of trusses • Analysis of beams and frames (bending and torsion problems) • Plane stress and plane strain analysis problems • Problems leading to analysis of axisymmetric solids • Problems leading to analysis of three dimensional solids • Heat transfer problems • Model analysis problems for natural frequency determination

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	TEXT BOOKS:- 1. "Finite Element Analysis: Theory and Application with ANSYS", S. Moaveni, Pearson Education Limited 2. "Engineering Analysis with ANSYS Workbench 18", G. Zhang, College House Enterprises REFERENCE BOOKS:- 1. "Finite Element Modeling and Simulation with ANSYS Workbench", X. Chen & Y. Liu, CRC Press 2. "Practical Aspects of Finite Element Simulation – A Student Guide", free ebook by Altair University 3. "Working with ANSYS: A Tutorial Approach", D. Zindani, A.K. Roy & K. Kumar, I.K. International Publishing House Pvt. Ltd. 4. "ANSYS Workbench 14.0 for Engineers and Designers", S. Tickoo, Dreamtech Press 5. "Introduction to ANSYS 16.0", R.B. Choudary, I.K. International Publishing House Pvt. Ltd.
7ANU10	**Minor Project**
	• The students are required to work in groups of not more than three students on a project related to Aerospace Engineering under the guidance of a faculty member in one of the labs in the college. • The project topic should be such that it enables them to bring into practice the theoretical concepts learnt as well as learn new concepts and has to be approved by Project Coordinator. • The students are required to meet their project guides at least once in a fortnight and maintain a record of the same in a project diary. • A feasible working strategy should be developed and presented within a month. • At least two mid-semester presentations should be organized by Project Coordinator to review the progress during the semester. • A technical report and presentation has to be submitted at the end of the semester for evaluation of the work. The Project Coordinator should preferably be one of the members of the external grading committee.
7ANU11	**Practical Training**
	All the students are required to give a presentation on the concepts learnt during industrial training after 3rd year, and to submit a report in standard format covering their entire work during the period.
7ANUDC	**Discipline & Extra-Curricular Activities**

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	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 8th Semester

Option-A:-

Codes	Syllabus
8ANU1	**Avionics**
	Introduction to Avionics: Basics of avionics, need of avionics in civil and military aircraft and space systems; Cockpit basics; Integrated avionics architecture, typical avionics system and subsystems. **Digital Avionics Bus Architecture:** Data buses MIL-STD-1553B, RS-232, RS-422, RS-485, AFDX, ARINC 664, ARINC 429, ARINC 629; Aircraft system interface. **Flight Deck and Display Systems**: Flight deck display technologies, CRT, LED, LCD, Touch screen, Head up display, Electronic instrumentation systems. **Audio and Communication Systems:** Aircraft audio systems, basic audio transmitter and receiver principles, VHF communication system, UHF communication systems. **Ranging and Landing Systems**: VHF omnidirectional range, VOR receiver principles, distance maturity equipment, principles of operation; Instrument landing system, localizer and glide slope. **Position Inertial and Navigation System**: Satellite navigation systems, GPS principles, triangulation, position accuracy, applications in aviation; Principle of operation of INS, navigation over earth, components of inertial navigation systems, accelerometers, gyros and stabilized platform. **Surveillance System**: ATC surveillance systems, principles and operations; Standards; Collision avoidance system; Ground proximity warning system. **Auto Flight System:** Basic principles of auto pilot, longitudinal and lateral auto pilot; Automatic flight control system; Fly-by-wire and fly-by-light technologies; Flight director systems; Flight management systems.

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	TEXT BOOKS:- 1. "Introduction to Avionics Systems", R.P.G. Collinson, Springer 2. "Introduction to Avionics", D.R. Cundy & R.S. Brown, Pearson REFERENCE BOOKS:- 1. "Digital Avionics Handbook", C.R .Spitzer, U. Ferrel & T. Ferrel, CRC Press 2. "Principles of Avionics", A. Helfrick, Avionics Communications Inc. 3. "Principles of Modern Avionics", S. Nagabhushana & N. Prabhu, I.K. International Publishing House 4. "Civil avionics system" & "Military Avionics Systems", I. Moir, A. Seabridge & M. Jukes, Wiley-Blackwell 5. "Avionics Fundamentals", Jeppensen, Aviall Services
8ANU2	**Refrigeration and Air-Conditioning**
	Introduction: Brief history and need of refrigeration and air conditioning, methods of producing cooling, ton of refrigeration, coefficient of performance, types and application of refrigeration and air condensing systems. **Refrigerants:** Classification, nomenclature, desirable properties; Eco-friendly refrigerants and environmental issues of refrigeration & air conditioning industry. **Vapour Compression Refrigeration (VCR) Systems:** Simple vapour compression refrigeration systems; Analysis of VCR cycle considering degrees of subcooling and superheating, VCR cycle on P-V, T-s and P-h diagrams; Actual VCR cycle; Comparison of VC cycle with air refrigeration cycle. **Aircraft Refrigeration System:** Necessity of cooling the aeroplane; Reversed Carnot cycle and its limitation; Reversed Brayton cycle; Bell-Coleman cycle; Aircraft refrigeration systems; Working and analysis of simple, bootstrap, reduced ambient and regenerative air refrigeration systems. **Psychrometry and Air-conditioning Processes**: Properties of moist air: specific humidity, dew point temperature, degree of saturation, relative humidity, wet bulb temperature; Psychrometric chart; Psychrometry of air conditioning processes; Mixing process and other basic processes in conditioning of air.

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	Human Comfort: Selection of inside design conditions; Thermal comfort, heat balance equation, factors affecting thermal comfort, effective temperature, comfort chart and factors governing effective temperature; Selection of outside design conditions. **Air-Conditioning Load Calculations:** Outside and inside design conditions, sources of heating load, sources of cooling load, heat transfer through structure, solar radiation, electrical applications, infiltration and ventilation, heat generation inside conditioned space. **Air Conditioning Systems and Duct Design:** Classifications, equipment selection; Air distribution system, all-air, all-water and air-water systems, single and central air conditioning systems; Duct systems design; Filters; Refrigerant piping; Temperature, pressure and humidity sensors; Actuators and safety controls, accessories. TEXT BOOKS:- 1. "Refrigeration & Air Conditioning", R.C. Jordan & G.B. Priester, Prentice Hall of India 2. "Refrigeration & Air Conditioning", C.P. Arora, McGraw Hill Education REFERENCE BOOKS:- 1. "Refrigeration and Air Conditioning", W.F. Stoecker & J.W. Jones, McGraw Hill Education 2. "Basic Refrigeration and Air Conditioning", P.N. Ananthanarayanan, McGraw Hill Education 3. "Refrigeration and Air Conditioning", Manohar Prasad, New Age International Private Limited 4. "Refrigeration and Air Conditioning", R.C. Arora, Prentice Hall India Learning Private Limited 5. "Refrigeration and Airconditioning: High Side Design", Arvind Agrawal, New Academic Science Limited
8ANU3	**Airport Management and Aircraft Maintenance**
	Introduction: The evolution of aviation, growth drivers, issues and challenges; Global aviation industry, major players in aviation industry in India, SWOT analysis of the different airline companies in India, market potential and current challenges of airline industry in India.

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	Aircraft Rules: ICAO, international environmental protection policies; Airport Authority of India, DGCA, Airport Economic Regulatory Authority of India; Aircraft Act 1934, The Aircraft Rules 1937, Civil Aviation Requirements (CAR); Aircraft manuals, Aeronautical Information Circulars. **Airport Planning and Management:** Functions of airports; Airport layouts and configurations; Airport terminal planning; Various airport services; Effect of privatization; An overview of any international airport. **Air Traffic Control:** Principles of air navigation and air traffic control; Classification of ATS air spaces; Assignment of cruising levels; Air traffic zones and approach areas, methodology for slot allocation, aerodrome data; Airport & aircraft security, crisis management at airports. **Airworthiness:** Knowledge of various mandatory documents issued to establish airworthiness of aircraft parts; Airworthiness requirement for gliders, micro light aircraft, ferry flight and hot air balloons; Load and trim sheet; Aircraft inspection, cockpit check list, preparation and use of concept and emergency check list, defect management; Various logbooks required to be maintained for aircraft and their purpose. **Maintenance of Aircraft Structural Components:** Types of maintenance schedules, damage investigation, non-destructive testing; Sheet metal repair and maintenance; Maintenance and repair of plastic components; Inspection and repair of composite components; Installation and maintenance of instruments; Inspection and maintenance of various aircraft systems such as power plant, landing gear system, air-conditioning and pressurization system, fuel & hydraulic system, position and warning system, auxiliary systems. **Licensing of Aircraft Maintenance Engineers:** Knowledge of privileges and responsibilities of the various categories of AME licence and approved persons; Duties of an aircraft maintenance engineer licence holder; Student flight engineer; Validation of foreign AME licence. TEXT BOOKS:- 1. "Airport Planning and Management", S.B. Young & A.T. Wells, McGraw-Hill Education 2. "Aviation Maintenance Management", H.A. Kinnison & T. Siddiqui, McGraw Hill Education

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	REFERENCE BOOKS:- 1. "Fundamentals of Aircraft Maintenance Management", H. Timothee, Notion Press 2. "Airport Management", C.D. Prather, Aviation Supplies & Academics Inc. 3. "Aircraft Maintenance and Repair", M. Kroes & R. Sterkenburg, McGraw Hill Education 4. "Aviation Management: Global and National Perspectives", Ratandeep Singh, Kanishka Publishing House 5. "Air Transportation: A Management Perspective", J.G. Wensveen, Routledge
8ANU4.1	**Missile Technology**
	Introduction: History of missiles, classification of missiles; Concept of guidance, peaceful application of guidance; Selection of materials for missiles. **Major Components of Missiles:** Airframe, flight control system, guidance subsystem, proximity fuse, warhead, propulsion system. **Missile Performance:** Aerodynamics characteristics of airframe components, forces and moments acting on a missile while passing through atmosphere, slender body aerodynamics, drag estimation; Equations of motion for three-dimensional motion through atmosphere and vacuum, one-dimensional and two-dimensional rocket motions in free space and homogeneous gravitational fields, description of vertical, inclined and gravity turn trajectories; Effect of earth's rotation, inertial and non-inertial frames, coordinate transformation; Powered and unpowered flight, boost-glide trajectory, boost-sustain trajectory, long range cruise trajectory, long range ballistic trajectory, re-entry conditions; Brief description of fin-stabilized and spin-stabilized missiles and their force systems; Manoeuvring flight: flat turns, pull-ups, relation between manoeuvrability & static stability margin; Multistaging of ballistic missiles, separation techniques. **Fundamentals of Guidance:** Different phases of missile; Homing guidance categories; Introduction to aerodynamic and jet control methods; Various types of aerodynamic control methods for tactical and short range missiles; Various types of thrust vector control methods; Interception and avoidance. **Rocket Propulsion:** Solid, liquid, hybrid rocket motor, single base propellants, double base propellants, composite propellants, CMBD propellants and their ingredients; Propellant grains and types of burns, erosive burning, pyrotechnic

	devices and systems, igniter & ignition system; Propellant mass fraction, thrust coefficient, characteristic velocity, burn rate, total impulse; Types of nozzles and thrust vector control. TEXT BOOKS:- 1. "Missile Design and Systems Engineering", E.L. Fleeman, American Institute of Aeronautics & Astronautics 2. "Missile Guidance and Control Systems", George M. Siouris, Springer REFERENCE BOOKS:- 1. "Tactical and Strategic Missile Guidance", P. Zarchan, AIAA 2. "Modern Missile Guidance", R. Yanushevsky, CRC Press 3. "Automatic Control of Aircraft And Missiles", John H. Blacelock, Wiley 4. "Missile Guidance and Pursuit: Kinematics, Dynamics and Control", N.A. Shneydor, Woodhead Publishing 5. "Rocket Propulsion and Spaceflight Dynamics", J.W. Cornelisse, H.F.R. Schöyer & K.F. Wakker, Pitman Publishing Limited
8ANU4.2	**Viscous Flows**
	Introduction: Ideal and real fluid, viscosity in real flows and its effect, d'Alembert's paradox; Laminar and turbulent flow; Vector and tensor notation; Material derivative; Acceleration, translation, rotation and distortion of fluid element; Shear stress and shear strain, Newtonian and non-Newtonian fluids, coefficient of dynamic viscosity and its variation with temperature, coefficient of kinematic viscosity; Physical significance of Reynolds number; Vorticity. **Conservation Laws:** Continuity equation for compressible and incompressible flows, conservative and non-conservative form; Derivation of Navier-Stokes equations and its simplification for incompressible flow, Stokes hypothesis; Energy conservation equation. **Exact Solution of Simplified Flows**: Internal viscous flow in pipes and ducts, Couette flow, lubrication theory, Hagen-Poiseuille flow, Unsteady parallel flow; External viscous flow over flat plates; Creeping flow, Stokes equations, Stokes law. **Laminar Boundary Layer:** Laminar boundary layer equations; Displacement, momentum and energy thickness, shape factor; Kármán momentum integral equation; Similarity solutions, Blasius solution, Kármán-Pohlhausen method for non-

	zero pressure gradient, Holsten and Bohlen method, Waltz's-Quadrature formula; Boundary layer separation, effect of pressure gradient, boundary layer control. **Turbulent Flows:** Introduction to turbulent flows, features of turbulence, energy cascade, turbulence length scales; Different modes of transition to turbulence; Intermittency factor, mean and fluctuating components, derivation of Reynolds Averaged Navier-Stokes equations, Reynolds stress tensor; Skin friction coefficients for hydrodynamic smooth and rough pipes, Darcy-Weisbach equation, Moody's chart; Turbulent boundary layer equations, eddy viscosity and mixing length hypothesis; Structure of turbulent boundary layer, universal law of wall, laminar sublayer, power law for turbulent boundary layer. TEXT BOOKS:- 1. "Viscous Fluid Flow", F.M. White, McGraw Hill Education 2. "Fluid Mechanics", P.K. Kundu, I.M. Cohen & D.R. Dowling, Academic Press REFERENCE BOOKS:- 1. "Boundary Layer Theory", H. Schlichting, McGraw Hill Education 2. "Viscous Flow", H. Ockendon & J.R. Ockendon, Cambridge University Press 3. "Fluid Mechanics", R.W. Fox, A.T. McDonald, P.J. Pritchard, J.W. Mitchell, Wiley India Edition 4. "Viscous Flows: The Practical Use of Theory", S.W. Churchill, Butterworth-Heinemann Ltd. 5. "Viscous Flow", Frederick S. Sherman, McGraw-Hill Inc.
8ANU4.3	**Fundamentals of Combustion**
	Introduction: Introduction to combustion, types of fuel and oxidizers, characterization of fuel, various combustion modes; Applications and scope of combustion; Aviation fuels requirements and specifications. **Thermodynamics of Combustion:** Thermodynamics properties; Laws of thermodynamics applied to reacting systems; Stoichiometry, equivalence ratio, equilibrium composition; Thermochemistry, relationship between bond energies and heats of formation, heats of reaction for constant-pressure and constant-volume combustion, adiabatic flame temperature; Chemical equilibrium, Clausius-Clapeyron equation for phase equilibrium.

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	Chemical Kinetics: Basic reaction kinetics, elementary reactions, chain reactions, multistep reactions; Simplification of reaction mechanism, global kinetics, reaction rates; Gas phase reactions, methods for measurement; Surface reactions. **Physics of Combustion:** Fundamental laws of transport phenomena; Premixed and diffusion flames; Laminar and turbulent flames; Detonation and deflagration waves of premixed gases, flame velocity in pre-mixed flame, flame speed measurement methods; Ignition, flammability limits, flame quenching; Gaseous jet diffusion flame; Droplet and spray combustion; Solid fuel combustion. **Combustion and Environment:** Atmosphere; Chemical emission from combustion; Quantification of emission; Emission control methods, introduction to bio fuels, green aviation. TEXT BOOKS:- 1. "Principles of Combustion", K.K. Kuo, Wiley India Pvt Ltd 2. "Fundamentals of Combustion", D. P. Mishra, Prentice Hall of India REFERENCE BOOKS:- 1. "Understanding Combustion", H.S. Mukunda, Universities Press 2. "An Introduction to Combustion: Concepts and Applications", S.R. Turns, McGraw Hill Education 3. "Combustion: Fundamentals and Application", Amitava Datta, Alpha Science International Ltd 4. "Fuels and Combustion", Samir Sarkar, Universities Press 5. "Introduction to Combustion Science", Randall Fletcher, Willford Press
8ANU4.4	**Operations Research**
	Introduction: Origin of operation research, historical standpoint; Methodology; Scope and application of operations research. **Linear Programming Problem:** Introduction, requirement of LP; Basic assumptions, formulation of LP, general statement of LP; Solution techniques of LP: Graphical methods, Analytical methods: simplex, big M and two phase; Sensitivity analysis.

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	Transportation and Assignment: Transportation problems definition; Linear form; Solution methods: Northwest corner method, least cost method, Vogel's approximation method; Trans-shipment problems; Travelling salesman problem. **Queuing Theory:** Basis of queuing theory, elements of queuing theory, Kendall's notation; Operating characteristics of a queuing system; Classification of queuing models. **Inventory Control:** Inventory classification; Different cost associated to inventory, economic order quantity; Inventory models with deterministic demands. **Replacement Theory:** Introduction; Replacement of capital equipment which depreciated with time, replacement by alternative equipment; Group and individual replacement policy. **Game Theory:** Introduction, characteristics of game theory; Two person zero sum games; Pure strategy; Dominance theory; Mixed strategies (2x2, mx2). **Decision Theory:** Introduction; Decision under certainty; Decision under risk; Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion; Decision tree. **Project Management:** Introduction to PERT and CPM; Critical path calculation. TEXT BOOKS:- 1. "Operations Research: An Introduction", Hamdy A. Taha, Pearson Education India 2. "Operations Research: Principles and Applications", G. Srinivasan, PHI Learning Private Limited REFERENCE BOOKS:- 1. "Operations Research: Applications and Algorithms", Wayne L. Winston, Duxbury Resource Center 2. "Introduction to Operations Research", F.S. Hillier, G.J. Lieberman, B. Nag & P. Basu, McGraw Hill Education 3. "Operations Research: Principles and Practice", Ravindran, Phillips & Solberg, Wiley 4. "Operations Research", P. Ramamurthy, New Age International 5. "Optimization in Operations Research", Ronald Rardin, Pearson Education

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8ANU5	**Avionics Lab**
	• Design and implementation of 4-bit adder and subtractor circuit using IC 7483 and IC 7486 • Implementation of multiplexer/demultiplexer circuits • Implementation of encoder/decoder circuits • Design and implementation of 4-bit shift register with D-flip flops using IC 7474 • Timer circuits, shift registers, binary comparator circuits • Addition and subtraction of 8-bit and 16-bit numbers • Sorting of data in ascending & descending order • Sum of a given series with and without carry • Multi-byte addition in BCD mode • Interface programming with 4-digit 7-segment display and switches and LEDs • 16 Channel Analog to Digital Converter & generation of ramp, square, triangular wave by Digital to Analog Converter • Use of data buses for message transfer • Remote Terminal Configuration of data bus
8ANU6	**Refrigeration and Air-Conditioning Lab**
	• Study of different types of expansion devices and evaporators used in refrigeration system • Evaluation of coefficient of performance of cycle and tonnage capacity of refrigeration unit • Calculation of theoretical and actual value of coefficient of performance on vapour compression test rig • Experiment on two-stage reciprocating compressor for determination of volumetric efficiency and effect of intercooling • Study of cut-sectional models of reciprocating, rotary and centrifugal compressor • Determination of coefficient of performance and refrigeration load of a chilling plant • Determination of coefficient of performance and tonnage capacity of a mechanical heat pump • Calculation of coefficient of performance of aqua-ammonia absorption system • Study of various controls used in refrigeration and air-conditioning system • Experiment on air-conditioning test rig & calculation of various performance parameters

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	• Study of different psychrometric processes & charts • Study of working principle of air refrigeration system using charts • Visit of central air conditioning plant and cold storage and detailed study of their different components
8ANU7	**Flight Simulation Lab**
	• Demonstration of working of ILS and VOR using flight simulator • Demonstration of autopilot, ADF and other navigation instruments using flight simulator • Demonstration of an aircraft starting procedure with checklist using flight simulator • Determination of an aircraft performance parameters at various flying conditions using real-time flight simulator • Execution of a complete cycle of flight profile using real-time flight simulator • Demonstration of autopilot mode flight operation using flight simulator • Stability analysis using Root locus, Bode plot, Nyquist plot and Polar plot techniques • Design of lead, lag and lead-lag compensator for aircraft dynamics • Performance improvement of aircraft dynamics by pole placement technique • Design of displacement longitudinal and lateral autopilot • Design of automatic glide slope control system and flare control system • Analysis of actuation mechanisms of an aircraft and helicopter using Arduino with the help of Mission Planner software • Estimation of aerodynamics derivatives from wind tunnel tests • Assessment of dynamic signatures and impact on performance of abnormal flight conditions through simulation and tests using PC-based simulation and a 6-DOF motion-based flight simulator • Assessment and analysis of the dynamic effects of aircraft propulsion system failure • Simulation of effect of deploying different control surfaces
8ANU8	**Seminar**
	The purpose of this course is to introduce students to the field of technical research and formal documentation of research work in the form of research papers and technical reports.

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	• Every student is required to select a seminar topic in emerging areas of science and technology broadly related to Aerospace Engineering different from those already covered in previous years, with the consent of Seminar Coordinator. • Each student will be allotted a faculty member to serve as Seminar Guide, under whose guidance the student is supposed to study and present the latest research work related to the topic. • The student should learn to study and summarize research works related to the topic, and identify the state-of-the-art on the chosen topic. • During the class timings, students will give interim presentations on their chosen topics in front of their section teachers. At least two presentations per student should be completed during the semester. • By the end of the semester, every student has to prepare a Seminar Report and a Seminar Presentation. The report should formally summarize the relevant research in the area and be divided into no less than 5 chapters encompassing at least 45 pages, and its formatting should be in accordance with the guidelines provided by Seminar Coordinator. The presentation should be for about 15 minutes and include important and interesting points related to the topic and be technically perfect with proper formatting and grammar. • For internal evaluation, 40 marks will be assigned by subject teacher allotted to the respective section based on the presentations given by the student during the semester, and 35 marks will be given by Seminar Guide according to his evaluation of efforts put by student. • The external grading would be done by a committee of external examiners chosen by Seminar Coordinator with the consent of Head of Department, on the basis of final report and presentation.
8ANU9	**Major Project**
	The primary objective of this course is to develop in students the professional quality of synthesis employing technical knowledge obtained in the field of engineering & technology through a project work involving design and analysis augmented with creativity, innovation and ingenuity. • The students are required to form groups of two to four students for the project work. • Each group should work under the guidance of a faculty member who will serve as the project mentor. A feasible and interesting project objective related to aerospace engineering should be chosen taking approval from Project Coordinator. • Each group should meet with its project mentor regularly and maintain the record of discussion in a project diary.

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	• The Project Coordinator should call regular meetings of all groups to monitor their regular progress in their projects, and give constructive suggestions as required. • For internal grading, the Project Coordinator would assign marks out of 90 based on regular assessment throughout the semester during project review meetings, and the project mentor would give marks out of 60 to each student based on his perception of sincerity of each student. • Each group has to prepare a technical report according to the guidelines provided by Project Coordinator. The report should contain introduction to the topic, technical background, objective, working methodology, detailed calculations, data analysis, results, discussion and the final conclusion of project. • The external evaluation would be done by external examiners allocated by HoD based on the final presentation, project demonstration and technical report. 30 marks may be allocated to the report, 30 marks to the presentation and 30 marks to the successful demonstration and realization of desired objectives.
8ANUDC	**Discipline & Extra Curricular Activities**
	As per UD, RTU norms

Option-B

8ANUI1	**Internship**
	Guidelines for Semester-long Internship Project (A) Duration • The duration of internship should be between 16 to 24 weeks. • The external mentor should ensure that the attendance record of the student is maintained daily and the record along with total number of permitted/ unpermitted leaves be handed to the department at the end of approved internship duration. (B) Nature of internship • Guiding principle behind internship would be improvement in knowledge/skills and employability of the students and emphasis would be on core companies and practical work on any project.

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- Students would be allowed internships in research institutes if they indicate profound interest in academics/ research.
- For non-core companies, the head of department should frame a policy by constituting a department level committee. For each student choosing to go to such an organization, the department level committee would review each case on its merit after receiving the justification from the student.
- The special opportunity for whole semester internship is optional, subject to the student getting a suitable and justifiable project work to replace the course work and project in the college. The permission shall be granted only on merit of the problem statement and the proposed organisation, not for general training similar to mandatory summer training after third year where information on some aspects may be provided without a well-defined project objective.

(C) Approval of Internship Request

- A student who wishes to undertake semester long internship outside the college should submit a cover letter containing the details of proposed work along with the approval letter from his proposed mentor as per the format provided by Project Coordinator by the end of November to the project coordinator.
- The project coordinator would forward the application with his specific comments to HoD, or in case of non-core companies to the departmental committee, which will then give its recommendation to HoD.
- Head of Department would be the final authority to sanction the request for outstation internship of any student.

(D) Monitoring

- Students whose outstation internship request is approved have to ensure that their joining reports in standard form provided by the department are received by the department within 15 days of joining, failing which the approval for internship may deemed to be cancelled.
- The concerned department may try to identify and request adjunct faculty/ experts/ RTU alumni to guide and monitor the work of the students working nearby their location.
- The students need to mail the monthly progress report signed by the official mentor to the project coordinator.
- The project coordinator should try to remain in touch with the students' project mentors via email/ phone to keep a watch on the progress of project work.

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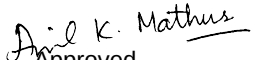
	(E) Preparation of Report • Each student needs to prepare a comprehensive report of the work as per guidelines given by the project coordinator. • A copy of the final report should be submitted to the internship organization at the end of project work and another copy signed by the project mentor to the project coordinator before the final external practical exam at the department. (F) Feedback • The project external mentor should fill an online feedback form regarding the performance of student during the stay at the end of the duration of internship using a link provided by project coordinator. • The student should also fill a feedback form regarding his/her experience during the internship for future reference. (G) Grading • External evaluation would be done by a panel of faculty members appointed by HoD based on the presentation given by student and final report submitted at the end of project duration. • 250 marks in the internal evaluation should be given by external mentor to the project coordinator confidentially in the online feedback form. • The remaining internal marks would be assigned by project coordinator based on regular submission of progress report, feedback from mentor and viva. (H) Certification • After successful completion of internship, a certificate should be provided by the host institute to the student with specific comment about his/ her performance. • The department will also provide a certificate to the student mentioning the project topic and place of internship.
8ANUI2	**Seminar**
	• Before proceeding for internship, the student has to choose a Seminar topic and get it approved by Seminar Coordinator. • A faculty member as Seminar Guide will be allotted to every student, and the student is required to keep working on the Seminar topic being in touch with his/her Seminar Guide by email/ phone throughout the semester.



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	• The Seminar Guide may ask the student to send interim report/ presentation on the topic, as deemed suitable to assess the efforts put by the student. The entire internal marks shall be allocated based on the discretion of Seminar Guide. • The student is supposed to complete the Seminar Report and presentation within the semester, and be present before the external examination committee at the scheduled date of external exam. The external marks would be assigned by the external examiners based on the report and presentation, giving almost equal weightage to both of them.

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