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**

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. **Fundamentals of Rocket Propulsion:** Brief history and principle of rocket; Rocket equation; Classification of rockets, mass ratio of rocket; 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. **Chemical Rockets:**Solid propellant rockets, important hardware components of solid 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;Criteria for choice of propellants;Introduction to hybrid rocket propulsion, applications and limitations of hybrid rockets.

	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. "Mechanics& Thermodynamics of Propulsion", P.G. Hill& C.R. Peterson, Addison-Wesley Longman Inc. REFERENCE BOOKS:- 1. "Aerospace Propulsion System", T.A. Ward, Wiley 2. "Theory of Aerospace Propulsion", P.M. Sforza, Butterworth-Heinemann 3. "Aircraft Engines and Gas Turbines", J.L. Kerrebrock, The MIT Press 4. "Hypersonic Air Breathing Propulsion", W.H. Heiser&D.T. Pratt, AIAA Education Series 5. "Gas Turbine & Jet Rocket Propulsion", M.L.Mathur, & R.P. Sharma, Standard Publishers Distributors
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 University Press 3. "General Aviation Aircraft Design: Applied Methods and Procedures", S.Gudmundsson, Butterworth-Heinemann 4. "Design of Aircraft", T.C. Corke, Prentice Hall
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 concepts 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:- 1. "Control Systems Design", B. Friedland, McGraw Hill 2. "Automatic Control of Aircraft and Missiles", J.H. Blackelock, John Wiley & Sons 3. "Flight Stability and Automatic Control", R. C. Nelson, McGraw Hill 4. "Control Systems", N.K. Sinha, New Age International Publishers
Syllabus of Elective Subjects	
7ANU6.1	**Non-Destructive Testing**
	Introduction to NDT: Fundamentals of non-destructive testing and evaluation; Visualinspection techniques; Advantages and limitations of NDT **Liquid penetrant testing:** Basic principle; Types of dye and methods of application; Developer application and

	Inspection. **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; Inspection system and probes, depth of penetration, eddy current response, 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. **Acoustic emission testing:** Basic principle, sources of acoustic emission, source parameters; Kaiser-Felicity theory; Equipment and data display. **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. TEXT BOOKS 1. "Non-destructive Testing", Louis Cartz, ASM International 2. "Practical Non-destructive Testing", B. Raj, T. Jayakumar & M. Thavasimuthu, Narosa Publishing House 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
7ANU6.2	**Artificial Intelligence**
	Machine Intelligence Technologies: Neural Networks; Introduction to Neural Networks; Perception Learning Rule; Hebbian Learning; Widrow-Hoff Learning; Back propagation; Associative Learning; Competitive Networks; Grossberg Networks and Adaptive Resonance Theory; Hopfield Networks. **Artificial Intelligence:** Introduction; Semantic Nets and Description Matching; Generate and Test, Means-Ends Analysis, and Problem Reduction; Nets, Basic Search, and Optimal Search; Trees and Adversarial Search; Rules and Rule Chaining; Planning. **Fuzzy Set Theory:** Introduction to Fuzzy Set with Properties; Fuzzy Relations; Fuzzy Arithmetic; Fuzzy Logic; Applications and Fuzzy Control. **Genetic Algorithm:** Introduction; Operations; Standard Method; Rank Method; Rank Space Method. **Particle Swarm Optimization:** Introduction to Swarm Behavior; Optimization. TEXT BOOKS:- 1. "Artificial Intelligence: A Modern Approach", S.J.Russell &P. Norvig, Pearson Education India REFERENCE BOOKS:- 1. "Artificial Intelligence", R. Knight, McGraw-Hill 2. "Neural Networks: AComprehensive Foundation", S. Haykin, Pearson Education 3. "Artificial Intelligence", P.H. Winston, Pearson Education 4. "Artificial Neural Networks", B. Yegnanarayana, Prentice Hall of India
7ANU6.3	**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 and requirements; Types and their uses; Materials for strain gauges, strain gauge adhesives;Gauge sensitivity and gauge factor; Calibration and temperature compensation;Wheatstone bridge and potentiometer circuits forstatic and dynamic strain measurements; Rosette analysis;Stress gauges;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 photo elasticity. **Brittle Coating and Moire Techniques:** Relation between stresses in coating and specimen, use of failure theories in brittle coating;Moiremethod of strain analysis. **Non-Destructive Testing:** Fundamentals of NDT;Acoustic Emission Technique; Radiography; Thermography; Ultrasonics; 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
7ANU6.4	**Fuel Cells and Hybrid Engine Technologies (common with 7MEU6.2)**

	Syllabus similar as UD Mechanical Engineering elective Fuel Cells and Hybrid Engine Technologies (7MEU6.2)
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)
7ANU8	**Aircraft Design Lab**
	The following steps should be carried out by all students in groups and give a presentation at the end of course. • 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 c.g. and its shift. • Estimation of aerodynamic characteristics and performance evaluation • Estimation ofspanwise load distributions on wing and tail • Internal design of wing and fuselage considering buckling loads and margin of safety • Estimation ofcost and airworthiness of airplane,trade-off studies TEXT BOOKS:- 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 TEXT BOOKS:- 1. "Finite Element Analysis: Theory and Application with ANSYS", S. Moaveni, Pearson Education Limited 2. "Practical Finite Element Analysis", N.S.Gokhale, S.S.Deshpande& S.V.Bedekar, Finite To Infinite REFERENCE BOOKS:- 1. "Practical Aspects of Finite Element Simulation – A Student Guide", free ebook by Altair University 2. "Working with ANSYS: A Tutorial Approach", D. Zindani, A.K. Roy & K. Kumar, I.K. International Publishing House Pvt. Ltd. 3. "ANSYS Workbench 14.0 for Engineers and Designers", S. Tickoo, Dreamtech Press 4. "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 four students in general on a project related to Aerospace Engineering under the guidance of a faculty member in one of the labs in the university. • 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. • A proper working strategy should be developed and presented within a month. • 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.

	• At least one mid-semester presentationduring the semestershould be held to review the progress. • A technical report and presentation for evaluation has to be made at the end of the semester.
7ANU11	**Practical Training**
	All the students are required to present 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 activity**
	As per UD, RTU Kota