VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

B.E. AERONAUTICAL ENGINEERING

III SEMESTER

Sl. No	Subject Code	Title	Teaching Dept.	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Drawing	Duration	Theory / Practical Marks	I.A. Marks	Total Marks	
1	17MAT31	ENGIINEERING MATHEMATICS-III	Mathematics	04		03	60	40	100	4
2	17AE32	ELEMENTS OF AERONAUTICS		04		03	60	40	100	4
3	17AE33	AERO THERMODYNAMICS		04		03	60	40	100	4
4	17AE34	MECHANICS OF MATERIALS		04		03	60	40	100	4
5	17AE35	MECHANICS OF FLUIDS		04		03	60	40	100	4
6	17AE36	MEASUREMENT & METROLOGY		03		03	60	40	100	3
7	17AEL37A / 17AEL37B	MEASUREMENT AND METROLOGY LAB/ MATERIAL TESTING LAB			1I+2P	03	60	40	100	2
8	17AEL38	MACHINE SHOP LAB			1I+2P	03	60	40	100	2
9	17KL/CPH39/49 Core Course	Kannada/Constitution of India, Professional Ethics & Human Rights	Humanities	01		01	30	20	50	1
TOTAL				**24**	**6**	**25**	**510**	**340**	**850**	**28**

1. Core subject: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2a. Foundation Course: The courses based upon the content that leads to Knowledge enhancement.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Engineering Mathematics - III

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	**17MAT31**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

The objectives of this course is to introduce students to the mostly used analytical and numerical methods in the different engineering fields by making them to learn Fourier series, Fourier transforms and Z-transforms, statistical methods, numerical methods to solve algebraic and transcendental equations, vector integration and calculus of variations.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 Fourier Series: Periodic functions, Dirichlet's condition, Fourier Series of periodic functions with period 2π and with arbitrary period 2c. Fourier series of even and odd functions. Half range Fourier Series, practical harmonic Analysis-Illustrative examples from engineering field.	**10 Hours**	**L1, L2 & L4**
Module -2 **Fourier Transforms**: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transform. **Z-transform**: Difference equations, basic definition, z-transform - definition, Standard z-transforms, Damping rule, Shifting rule, Initial value and final value theorems (without proof) and problems, Inverse z-transform. Applications of z-transforms to solve difference equations.	**10 Hours**	**L2, L3 & L4**
Module -3 **Statistical Methods**: Review of measures of central tendency and dispersion. Correlation-Karl Pearson's coefficient of correlation-problems. Regression analysis-lines of regression (without proof) –problems Curve Fitting: Curve fitting by the method of least squares- fitting of the curves of the form, $y= ax + b$, $y = ax^2+ bx + c$ and $y = ae^{bx}$. Numerical Methods: Numerical solution of algebraic and transcendental equations by Regula- Falsi Method and Newton-Raphson method.	**10 Hours**	**L3**
Module -4 **Finite differences:** Forward and backward differences, Newton's forward and backward interpolation formulae. Divided differences-	**10 Hours**	**L3**

Newton's divided difference formula. Lagrange's interpolation formula and inverse interpolation formula (all formulae without proof)-problems. **Numerical integration**: Simpson's $(1/3)^{th}$ and $(3/8)^{th}$ rules, Weddle's rule (without proof) – Problems.		
Module -5 **Vector integration**: Line integrals-definition and problems, surface and volume integrals-definition, Green's theorem in a plane, Stoke s and Gauss-divergence theorem (without proof) and problems. Calculus of Variations: Variation of function and Functional, variational problems. Euler's equation, Geodesics, hanging chain, problems.	**10 Hours**	**L3 & L4** **L2 & L4**

Course outcomes:

After studying this course, students will be able to:

1. Know the use of periodic signals and Fourier series to analyze circuits and system communications.
2. Explain the general linear system theory for continuous-time signals and digital signal processing using the Fourier Transform and z-transform.
3. Employ appropriate numerical methods to solve algebraic and transcendental equations.
4. Apply Green's Theorem, Divergence Theorem and Stokes ' theorem in various applications in the field of electro-magnetic and gravitational fields and fluid flow problems.
5. Determine the extremals of functionals and solve the simple problems of the calculus of variations

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Life-Long Learning.
- Accomplishment of Complex Problems.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. B.S. Grewal: Higher Engineering Mathematics, Khanna Publishers, 43rd Ed., 2015.
2. E. Kreyszig: Advanced Engineering Mathematics, John Wiley & Sons, 10th Ed., 2015.

Reference Books:

1. N.P. Bali and Manish Goyal: A Text Book of Engineering Mathematics, Laxmi Publishers, 7th Ed., 2010.
2. B.V. Ramana: "Higher Engineering Mathematics" Tata McGraw-Hill, 2006.
3. H. K. Dass and Er. RajnishVerma: "Higher Engineering Mathematics", S. Chand publishing, 1st edition, 2011.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Elements of Aeronautics

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	**17AE32**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. To know the history and basic principle of aviation
2. To understand the foundation of flight, aircraft structures, material aircraft propulsion
3. To develop an understanding stability of an aircraft along with its different systems

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction to Aircrafts** History of aviation; Atmosphere and its properties; Classification of aircrafts; Basic components of an aircraft; structural members; aircraft axis system; aircraft motions; control surfaces and high lift devices; classification of aircraft; conventional design configurations; principle of operation of each major part; Helicopters, their parts and functions. **Aircraft Structures and Materials:** Introduction; general types of construction; monocoque, semi-monocoque and geodesic structures; typical wing and fuselage structure; metallic and non-metallic materials for aircraft application.	**10 Hours**	**L1, L2**
Module -2 **Basic principles of flight** – significance of speed of sound; airspeed and groundspeed; standard atmosphere; Bernoulli's theorem and its application for generation of lift and measurement of airspeed; forces over wing section, aerofoil nomenclature, pressure distribution over a wing section. Lift and drag components – generation of lift and drag; lift curve, drag curve, types of drag, factors affecting lift and drag; centre of pressure and its significance; aerodynamic centre, aspect ratio, Mach number and supersonic flight effects; simple problems on lift and drag.	**10 Hours**	**L1, L2**
Module -3 **Aircraft Propulsion:** Aircraft power plants, classification based on power plant and location and principle of operation. Turboprop, turbojet and turbofan engines; ramjets and scramjets; performance characteristics. Aircraft power plants – basic principles of piston, turboprop and jet engines; Brayton	**10 Hours**	**L1, L2, L3**

cycle and its application to gas turbine engines; use of propellers and jets for production of thrust; comparative merits and limitations of different types of propulsion engines; principle of thrust augmentation.		
Module -4 **Aircraft Stability:** Forces on an aircraft in flight; static and dynamic stability; longitudinal, lateral and roll stability; necessary conditions for longitudinal stability; basics of aircraft control systems. Effect of flaps and stats on lift, control tabs, stalling, gliding, landing, turning, aircraft manoeuvres; stalling, gliding, turning. Simple problems on these. Performance of aircraft – power curves, maximum and minimum speeds for horizontal flight at a given altitude; effect of changes in engine power and altitude on performance; correct and incorrect angles of bank; aerobatics, inverted manoeuvre, manoeuvrability. Simple problems.	**10 Hours**	**L1, L2**
Module -5 **Aircraft Systems:** Mechanical systems and their components; hydraulic and pneumatic systems; oxygen System; environmental Control System; fuel system. Electrical systems, flight deck and cockpit systems; navigation system, communication system. **Aircraft systems (Mechanical) –** hydraulic and pneumatic systems and their applications; environment control system; fuel system, oxygen system. **Aircraft systems (Electrical)** – flight control system, cockpit instrumentation and displays; communication systems; navigation systems; power generation systems – engine driven alternators, auxiliary power Module, ram air turbine; power conversion, distribution and management.	**10 Hours**	**L1, L2**

Course outcomes:

After studying this course, students will be able to:

1. Appreciate and apply the basic principle of aviation
2. Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft propulsion and aircraft materials during the development of an aircraft
3. Comprehend the complexities involved during development of flight vehicles.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. John D. Anderson, “Introduction to Flight”, McGraw-Hill Education, 2011, ISBN 9780071086059.
2. Lalit Gupta and O P Sharma, “Fundamentals of Flight Vol-I to Vol-IV”, Himalayan Books, 2006.

Reference Books:

1. A.C. Kermode, “Flight without formulae”, Pearson Education India, 1989. ISBN: 9788131713891.
2. Nelson R.C., “Flight stability and automatic control”, McGraw-Hill International Editions, 1998. ISBN 9780071158381.
3. Ian Moir, Allan Seabridge, “Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration”, John Wiley & Sons, 2011, ISBN: 978111965006.
4. Sutton G.P., “Rocket Propulsion Elements”, John Wiley, New York, 8th Ed., 2011; ISBN: 1118174208, 9781118174203.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Aerothermodynamics

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

Subject Code	**17AE33**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand various concepts and definitions of thermodynamics.
2. Comprehend the I-law and II-law of thermodynamics.
3. Acquire the knowledge of various types of gas cycles

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Fundamental Concepts & Definitions:** Thermodynamics definition and scope, Microscopic and Macroscopic approaches. Some practical applications of engineering thermodynamic Systems, Characteristics of system boundary and control surface, examples. Thermodynamic properties; definition and Modules, intensive and extensive properties. Thermodynamic state, state point, state diagram, path and process, quasi-static process, cyclic and non-cyclic processes; Thermodynamic equilibrium; definition, mechanical equilibrium; diathermic wall, thermal equilibrium, chemical equilibrium. Zeroth law of thermodynamics, Temperature; concepts, scales, fixed points and measurements. **Work and Heat:** Mechanics-definition of work and its limitations. Thermodynamic definition of work; examples, sign convention. Displacement work; as a part of a system boundary, as a whole of a system boundary, expressions for displacement work in various processes through p-v diagrams. Shaft work; Electrical work. Other types of work. Heat	**10 Hours**	**L1, L2**
Module -2 **First Law of Thermodynamics:** Joules experiments, equivalence of heat and work. Statement of the First law of thermodynamics, extension of the First law to non - cyclic processes, energy, energy as a property, modes of energy, pure substance; definition, two-property rule, Specific heat at constant volume, enthalpy, specific heat at constant pressure. Extension of the First law to control volume; steady state-steady flow energy equation, important applications, analysis of unsteady processes such as film and evacuation of vessels with and without heat transfer.	**10 Hours**	**L1, L2, L3**

Module -3 **Second Law of Thermodynamics:** Devices converting heat to work; (a) in a thermodynamic cycle, (b) in a mechanical cycle. Thermal reservoir. Direct heat engine; schematic representation and efficiency. Devices converting work to heat in a thermodynamic cycle; reversed heat engine, schematic representation, coefficients of performance. Kelvin - Planck statement of the Second law of Thermodynamics; PMM I and PMM II, Clausius statement of Second law of Thermodynamics, Equivalence of the two statements; Reversible and Irreversible processes; factors that make a process irreversible, reversible heat engines, Carnot cycle, Carnot principles. **Entropy:** Clasius inequality; Statement, proof, application to a reversible cycle. Entropy; definition, a property, change of entropy, principle of increase in entropy, entropy as a quantitative test for irreversibility, calculation of entropy using Tds relations, entropy as a coordinate. Available and unavailable energy.	**10 Hours**	**L1, L2**
Module -4 **Pure Substances & Ideal Gases**: Mixture of ideal gases and real gases, ideal gas equation, compressibility factor use of charts. P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, Saturated liquid, mixture of saturated liquid and vapour, saturated vapour and superheated vapour states of pure substance with water as example. Enthalpy of change of phase (Latent heat). Dryness fraction (quality), T-S and H-S diagrams, representation of various processes on these diagrams. **Thermodynamic relations** Maxwells equations, Tds relations, ratio of heat capacities, evaluation of thermodynamic properties from an equation of state	**10 Hours**	**L1, L2, L3**
Module -5 **Gas Cycles:** Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, P-V & T-S diagram, calculation of efficiency; Carnot vapour power cycle, simple Rankine cycle, Analysis and performance of Rankine Cycle, Ideal and practical regenerative Rankine cycles – Reheat and Regenerative Cycles, Binary vapour cycle.	**10 Hours**	**L1, L2, L3**
Course outcomes: After studying this course, students will be able to: 1. Apply the concepts and definitions of thermodynamics. 2. Differentiate thermodynamic work and heat and apply I law and II law of thermodynamics to different process. 3. Apply the principles of various gas cycles		

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions.
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. A Venkatesh, “Basic Engineering Thermodynamics”, Universities Press, India, 2007, ISBN 13: 9788173715877
2. P K Nag, “Basic and Applied Thermodynamics”, 2nd Ed., Tata McGraw Hill Pub. 2002, ISBN 13: 9780070151314

Reference Books:

1. Yunus A. Cenegal and Michael A. Boles, “Thermodynamics: An Engineering Approach”, Tata McGraw Hill publications, 2002, ISBN 13: 9780071072540
2. J.B. Jones and G.A. Hawkins, John Wiley and Sons, “Engineering Thermodynamics”, Wiley 1986, ISBN 13: 9780471812029
3. G.J. Van Wylen and R.E. Sonntag, “Fundamentals of Classical Thermodynamics”, Wiley Eastern, Wiley, 1985, ISBN 13: 9780471800149
4. Y.V.C. Rao, “An Introduction to Thermodynamics”, Wiley Eastern, 1993, ISBN 13: 9788173714610.
5. B.K Venkanna, Swati B. Wadavadagi “Basic Thermodynamics”, PHI, New Delhi, 2010, ISBN 13: 978-8120341128.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Mechanics of Materials

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	**17AE34**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Comprehend the basic concepts of strength of materials.
2. Acquire the knowledge of stress, strain under different loadings.
3. Understand the different failure theory.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Basic equations of linear elasticity:** The concept of stress, Analysis of the state of stress at a point, Equilibrium equations, The state of plane stress, The concept of strain, Analysis of the state of strain at a point, Plane strain and plane stress in polar coordinates, Problem featuring cylindrical symmetry. **Constitutive behaviour of materials:** Constitutive laws for isotropic materials, Allowable stress, Yielding under combined loading, Material selection for structural performance, Composite materials, Constitutive laws for anisotropic materials, Strength of a transversely isotropic lamina. **Engineering structural analysis**: Solution approaches, Bar under constant axial force, Pressure vessels.	**10 Hours**	**L1, L2**
Module -2 **Euler-Bernoulli beam theory:** The Euler-Bernoulli assumptions, Implications of the Euler-Bernoulli assumptions, Stress resultants Beams subjected to axial loads, Beams subjected to transverse loads, Beams subjected to combined axial and transverse loads. **Three-dimensional beam theory:** Kinematic description, Sectional constitutive law, Sectional equilibrium equations, governing equations, Decoupling the three-dimensional problem, The principal centroidal axes of bending. The neutral axis, Evaluation of sectional stiffness.	**10 Hours**	**L1, L2. L3**
Module -3 **Torsion:** Torsion of circular cylinders, Torsion combined with axial force and bending moments, Torsion of bars with arbitrary cross-	**10 Hours**	**L1, L2, L3**

sections, Torsion of a thin rectangular cross-section, Torsion of thin-walled open sections. **Thin-walled beams:** Basic equations for thin-walled beams, Bending of thin-walled beams, Shearing of thin-walled beams. The shear centre. Torsion of thin-walled beams, Coupled bending-torsion problems Warping of thin-walled beams under torsion. Equivalence of the shear and twist centres, Non-uniform torsion, Structural idealization.		
Module -4 **Virtual work principles:** Introduction, Equilibrium and work fundamentals, Principle of virtual work, Principle of virtual work applied to mechanical systems, Principle of virtual work applied to truss structures. Principle of complementary virtual work, internal virtual work in beams and solids. **Energy methods:** Conservative forces, Principle of minimum total potential energy, Strain energy in springs, Strain energy in beams, Strain energy in solids, Applications to trusses, Development of a finite element formulation for trusses, Principle of minimum complementary, Energy theorems, Reciprocity theorems, Saint-Venant's principle.	**10 Hours**	**L1, L2, L3, L4**
Module -5 **Yielding:** Yielding under combined loading, Applications of yield criteria to structural, Application to bars, trusses and beams. Buckling of beams: Rigid bar with root torsion spring, buckling of beams, buckling of sandwich beams. Shearing deformations in beams, Shear deformable beams: an energy approach. **Kirchhoff plate theory:** Governing equations of Kirchhoff plate theory, The bending problem, Anisotropic plates, Solution techniques for rectangular plates, Circular, Energy formulation of Kirchhoff plate theory, Buckling of plates.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts of strength of materials.
2. Compute stress, strain under different loadings.
3. Distinguish the different failure theories.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. S.S. Bhavaikatii, “Strength of Materials”, Vikas Publications House, New Delhi, 2012, ISBN-13: 978-8125927914.
2. Timoshenko and Young “Elements of Strength of Materials’, East-West Press, 1976, ISBN 10: 8176710199.

Reference Books:

1. Beer. F.P. and Johnston. R, “Mechanics of Materials”, McGraw Hill Publishers, 2006, ISBN-13: 978-0073380285.
2. S. Ramamrutham, R Narayanan, “Strength of Materials”, Dhanapath Rai Publishing Company, New Delhi, 2012, ISBN 13: 9789384378264
3. Bao Shihua, Gong Yaoqing “Structural Mechanics” Wuhan University of Technology Press, 2005, ISBN: 7562924074 9787562924074
4. T.H.G Megson “Introduction to Aircraft Structural Analysis”, Butterworth-Heinemann Publications, 2007, ISBN 13: 9781856179324

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Mechanics of Fluid

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	**17AE35**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the basic fluid properties.
2. Understand the governing laws of fluid flow.
3. Acquire the knowledge of types of fluid flows.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Basic Considerations:** Introduction, Dimensions- Modules and physical quantities, Continuum view of gases and liquids, Pressure and Temperature scales, Physical properties of fluids. **Fluid Statics:** Pressure distribution in a static fluid, Pressure and its measurement, hydrostatic forces on plane and curved surfaces, buoyancy, illustration by examples.	**10 Hours**	**L1, L2**
Module -2 **Fluids in motion:** Methods of describing fluid motion, types of fluid flow, continuity equation in 3 dimensions, velocity potential function and stream function. Types of motion, Source sink, doublet, plotting of stream lines and potential lines Numerical problems. **Fluid Kinematics:** Kinematics of fluid motion and the constitutive equations, Integral (global) form of conservation equations (mass, momentum, energy) and applications, Differential form of conservation equations (continuity, Navier-Stokes equations, energy equation).	**10 Hours**	**L1, L2**
Module -3 **Fluid Dynamics:** Equations of motion: Euler's and Bernoulli's equation of motion for ideal and real fluids. Momentum equation, Fluid flow measurements. Numerical problems.	**10 Hours**	**L1, L2**

Dimensional analysis and similarity: Dimensional homogeneity, methods of dimensional analysis, model analysis, types of similarity and similitude. Dimensionless numbers. Model laws. Numerical problems.		
Module -4 **Flow past Immersed bodies:** Introduction to boundary layer, boundary layer thickness, karman's integral momentum theory, drag on a flat plate for laminar and turbulent flow, Drag on immersed bodies. Expression for drag and lift. Kutta – joukowsky theorem; Fundamentals of aerofoil theory Numerical problems.	**10 Hours**	**L1, L2, L3**
Module -5 **Compressible flow and Boundary Layers theory**: Steady, one-dimensional gas dynamics, Propagation of pressure waves in a compressible medium, velocity of sound, Mach number, Mach cone, Stagnation properties, Bernoulli's eqn for isentropic flow, normal shock waves. Numerical Problem; Laminar and turbulent boundary layers.	**10 Hours**	**L1, L2, L3. L4**

Course outcomes:

After studying this course, students will be able to:

1. Evaluate the effect of fluid properties.
2. Apply the governing laws of fluid flow.
3. Classify different types of fluid flows.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions.
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Bansal, R.K, "Fluid Mechanics and Hydraulics Machines", Laxmi Publications (P) Ltd., New Delhi 2015, ISBN-13: 978-8131808153.
2. Rathakrishnan. E, "Fluid Mechanics", Prentice-Hall of India Pvt. Ltd, 2010, ISBN 13: 9788120331839.

Reference Books:

1. Yunus A. Cengel & John M Cimbala, Fluid Mechanics and Applications, McGraw Hill Education; 3rd edition, 2013, ISBN-13: 978-0073380322.
2. Ramamritham. S "Hydraulic Fluid Mechanics and Fluid Machines", Dhanpat Rai& Sons, Delhi, 1988, ISBN 13: 9788187433804.
3. Kumar. K.L., "Engineering Fluid Mechanics" (VII Ed.) Eurasia Publishing House (P) Ltd., New Delhi, 1995, ISBN 13: 9788121901000.
4. Streeter. V. L., and Wylie, E.B., "Fluid Mechanics", McGraw Hill, 1983, ISBN 13: 9780070665781

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Measurement and Metrology

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

Subject Code	**17AE36**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objectives: This course will enable students to

1. Understand the standards of measurement, system of limits, fits, tolerances and gauging.
2. Understand the principles of measuring instruments
3. Acquire the knowledge on measurement and measurement systems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Standards of measurement:** Definition and Objectives of metrology, Standards of length - International prototype meter, Imperial standard yard, Wave length standard, subdivision of standards, line and end standard, comparison, transfer from line standard to end standard, calibration of end bars (Numerical), Slip gauges, Wringing phenomena, Indian Standards (M-81, M-112), Numerical problems on building of slip gauges.	**10 Hours**	**L1, L2, L3**
Module -2 **System of limits, Fits, Tolerances and gauging:** Definition of tolerance, Specification in assembly, Principle of inter changeability and selective assembly limits of size, Indian standards, concept of limits of size and tolerances, compound tolerances, accumulation of tolerances, definition of fits, types of fits and their designation (IS 919 -1963), geometrical tolerance, positional - tolerances, hole basis system, shaft basis of system, classification of gauges, brief concept of design of gauges (Taylor's principles), Wear allowance on gauges, Types of gauges -plain plug gauge, ring Gauge, snap gauge, limit gauge and gauge materials.	**10 Hours**	**L1, L2**
Module -3 **Comparators and Angular measurement:** Introduction to Comparator, Characteristics, classification of comparators, mechanical comparators - Sigma Comparators, dial indicator, Optical Comparators - principles, Zeiss ultra optimeter, Electric and Electronic Comparators - principles, Pneumatic Comparators, back pressure gauges, Solex	**10 Hours**	**L1, L2, L3**

Comparators. Angular measurements, Bevel Protractor, Sine Principle and. use of Sine bars, Sine center, use of angle gauges, Clinometers, **Screw thread gear measurement:** Terminology of screw threads, measurement of major diameter, minor diameter pitch, angle and effective diameter of screw threads by 2-wire and 3-wire methods, Best size wire. Gear tooth vernier.		
Module -4 **Measurements and Measurement systems:** Definition, Significance of measurement, generalized measurement system, definitions and concept of accuracy, precision, calibration, threshold, sensitivity, hysteresis, repeatability, linearity, loading effect, system response-times delay. Errors in Measurements, Classification of Errors. Transducers, Transfer efficiency, Primary and Secondary transducers, electrical, Mechanical, electronic transducers, advantages of each type transducers.	**10 Hours**	**L1, L2, L3**
Module -5 **Measurement of quantities:** Principle, analytical balance, platform balance, proving ring, Torque measurement, Prony brake, hydraulic dynamometer. Pressure Measurements, Principle, use of elastic members, Bridgeman gauge, Mcloed gauge, Pirani Gauge. **Temperature and strain measurement:** Resistance thermometers, thermocouple, law of thermocouple, materials used for construction, pyrometer, Optical Pyrometer. Strain Measurements, Strain gauge, preparation and mounting of strain gauges, gauge factor, methods of strain measurement	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Apply the standards of measurement, system of limits, fits, tolerances and gauging.
2. Identify and use appropriate measuring instruments.
3. Acquire the knowledge on measurement and measurement systems

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Beckwith Marangoni and Lienhard, John H. Lienhard V "Mechanical Measurements", 6th Ed., 2006, ISBN-13: 978-0201847659.
2. R.K. Jain "Engineering Metrology", Khanna Publishers, 1994, ISBN 13: 9788174091536

Reference Books:

1. I.C. Gupta "Engineering Metrology" Dhanpat Rai Publications, Delhi, 2013, ISBN 13: 1234567144039.
2. Alsutko, Jerry. D. Faulk "Industrial Instrumentation", Thompson Asia Pvt. Ltd.2002, ISBN-13: 978-0827361256

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

MEASUREMENTS AND METROLOGY LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	**17AEL37A**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course objectives: This course will enable students to

1. Learn the concepts of mechanical measurements and metrology
2. Use the concept of accuracy, error and calibration
3. Use the basic metrological instruments

Modules	**Revised Bloom's Taxonomy (RBT) Level**
1. Calibration of Pressure Gauge	**L1, L2, L3, L4**
2. Calibration of Thermocouple	**L1, L2, L3, L4**
3. Calibration of LVDT	**L1, L2, L3, L4**
4. Calibration of Load cell	**L1, L2, L3, L4**
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.	**L1, L2, L3, L4, L5**
6. Comparison and measurements using vernier caliper and micrometer	**L1, L2, L3, L4**
7. Measurement of vibration parameters using vibration setup.	**L1, L2, L3, L4**
8. Measurements using Optical Projector / Toolmaker Microscope.	**L1, L2, L3**
9. Measurement of angle using Sine Center / Sine bar / bevel protractor	**L1, L2, L3**
10. Measurement of alignment using Autocollimator / Roller set	**L1, L2, L3**
11. Measurement of Screw thread Parameters using Two-wire or Three-wire method.	**L1, L2, L3**
12. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator	**L1, L2, L3**

13. Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer	**L1, L2, L3**
14. Calibration of Micrometer using slip gauges.	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Identify and classify different measuring tools related to experiments.
2. Identify, define, and explain accuracy, precision, and some additional terminology.
3. Conduct, Analyze, interpret, and present measurement data from measurements experiments.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data.

MATERIAL TESTING LAB

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – III

Subject Code	**17AEL37B**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course objectives: This course will enable students to

1. Understand the relations among materials and their properties.
2. Understand the formation, properties and significance of the alloys through different experiments.
3. Understand the types, advantages and applications of various NDT methods.

Modules	Revised Bloom's Taxonomy (RBT) Level
1. Hardness Testing – Vicker's, Brinell, Rockwel	**L1, L2, L3**
2. Tensile Test	**L1, L2, L3, L4, L5**
3. Flexural Test	**L1, L2, L3, L4, L5**
4. Torsional Test	**L1, L2, L3**
5. Impact Test	**L1, L2, L3**
6. Shear Test	**L1, L2, L3**
7. Fatigue Test	**L1, L2, L3, L4, L5**
8. Preparation of specimen for metallograpic examination of different engineering materials. Identification of microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & metal matrix composites	**L1, L2, L3**
9. Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-treated samples.	**L1, L2, L3**
10. To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.	**L1, L2, L3**
11. Visual Testing Technique, Dye penetration testing. To study the defects of Cast and Welded specimens.	**L1, L2, L3**

12. Magnetic Particle Inspection.	**L1, L2, L3**
13. Ultrasonic Inspection.	**L1, L2, L3**
14. Eddy Current Inspection	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Apply the relations among materials and their properties.
2. Differentiate the formation, properties and significance of the alloys through different experiments.
3. Differentiate the types, advantages and applications of various NDT methods.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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MACHINE SHOP LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – III

Subject Code	**17AEL38**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course objectives: This course will enable students to

1. Practice general-purpose machine tools and manufacturing process.
2. Operate the special purpose machine tools
3. Prepare physical models using different manufacturing processes.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
1. Introduction to Machining operations & tools (Lath machine & shaper machine etc.)	**L1, L2**
2. Machining and machining time estimation for plain turning, taper turning & step turning.	**L1, L2, L3**
3. Machining and machining time estimation for thread cutting	**L1, L2, L3**
4. Machining and machining time estimation for knurling	**L1, L2, L3**
5. Machining and machining time estimation for knurling operation	**L1, L2, L3**
6. Machining and machining time estimation for drilling operation	**L1, L2, L3**
7. Machining and machining time estimation for boring operation	**L1, L2, L3**
8. Machining and machining time estimation for internal thread cutting	**L1, L2, L3**
9. Machining and machining time estimation for external thread cutting	**L1, L2, L3**
10. Machining and machining time estimation for eccentric turning	**L1, L2, L3**
11. Machining of hexagon in shaping machine	**L1, L2, L3**
12. Machining of square in shaping machine	**L1, L2, L3**
13. Cutting of gear teeth using milling machine	**L1, L2, L3**
14. Grinding operations using grinding machine.	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Demonstrate the operation of general purpose machine tools and manufacturing process.
2. Identify the special purpose machine tools for specific requirements

3. Develop physical models using different manufacturing processes.

Conduct of Practical Examination:
1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

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CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

B.E. AERONAUTICAL ENGINEERING

IV SEMESTER

Sl. No	Subject Code	Title	Teaching Dept.	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Drawing	Duration	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	17MAT 41	ENGINEERING MATHEMATICS-IV	Mathematics	04		03	60	40	100	4
2	17AE42	AERODYNAMICS -I		04		03	60	40	100	4
3	17AE43	AIRCRAFT PROPULSION		04		03	60	40	100	4
4	17AE44	MECHANISMS AND MACHINE THEORY		04		03	60	40	100	4
5	17AE45	AIRCRAFT MATERIAL SCIENCE		04		03	60	40	100	4
6	17AE46	TURBOMACHINES		03		03	60	40	100	3
7	17AEL47 A/17AEL47B	MATERIAL TESTING LAB/ MEASUREMENT AND METROLOGY LAB			1I+2 P	03	60	40	100	2
8	17AEL48	COMPUTER AIDED AIRCRAFT DRAWING			1I+2 P	03	60	40	100	2
9	17KL/CPH39/49 Core Course	Kannada/Constitution of India, Professional	Humanities	1		1	30	20	50	1
		TOTAL		**24**	**06**	**25**	**510**	**340**	**850**	**28**

1. Core subject: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2a. Foundation Course: The courses based upon the content that leads to Knowledge enhancement.

Semester IV
Engineering Mathematics IV

Course Code: **17MAT41** **IA Marks: 40**
Hours/Week: 4 hours **Exam Hours: 03**
Total Hours: 50 **Exam Marks: 60**

Course Learning Objectives:

The objective is to provide students with mathematics fundamental, necessary to formulate, solve and analyze engineering problems by making them to learn the following topics

- Numerical methods to solve ordinary differential equations
- Finite difference method to solve partial differential equations

- Complex analysis
- Sampling theory
- Joint probability distribution and stochastic process

Module 1 **10 Hrs**

Numerical Methods: Numerical solution of ordinary differential equations of first order and first degree, Picard's method, Taylor's series method, modified Euler's method, Runge - Kutta method of fourth order. Milne's and Adams-Bashforth predictor and corrector methods (No derivations of formulae).

Numerical solution of simultaneous first order ordinary differential equations, Picard's method, Runge-Kutta method of fourth order.

Module 2 **10 Hrs**

Numerical Methods: Numerical solution of second order ordinary differential equations, Picard's method, Runge-Kutta method and Milne's method

Special Functions: Bessel's functions- basic properties, recurrence relations, orthogonality and generating functions. Legendre's functions - Legendre's polynomial, Rodrigue's formula, problems.

Module 3 **10 hrs**

Complex Variables: Function of a complex variable, limits, continuity, differentiability, Analytic Functions-Cauchy-Riemann equations in Cartesian and polar forms. Properties and construction of analytic functions. Complex line Integrals-Cauchy's theorem and Cauchy's integral formula, Residue, poles, Cauchy's Residue theorem with proof and problems.

Transformations: Conformal transformations, discussion of transformations: $w = z^2, w = e^z, w = z + (a^2/z)$ and bilinear transformations.

Module 4 **10 hrs**

Probability Distributions: Random variables (discrete and continuous), probability functions. Binomial distribution, Poisson distribution**,** geometric distribution, uniform distribution, Exponential and normal distributions, Problems.

Joint probability distribution: Joint Probability distribution for two variables, expectation, covariance, correlation coefficient.

Module 5 **10 hrs**

Sampling Theory: Sampling, Sampling distributions, standard error, test of hypothesis for means and proportions, confidence limits for means, student's t-distribution, Chi-square distribution as a test of goodness of fit.

Stochastic process

Stochastic process, probability vector, stochastic matrices, fixed points, regular stochastic matrices, Markov chains, higher transition probability.

Course outcomes:

At the end of the course student will be able to:

1. Use appropriate numerical methods to solve first and second order ordinary differential equations.
2. Use Bessel's and Legendre's function which often arises when a problem possesses axial and spherical symmetry, such as in quantum mechanics, electromagnetic theory, hydrodynamics and heat conduction.
3. State and prove Cauchy's theorem and its consequences including Cauchy's integral formula, compute residues and apply the residue theorem to evaluate integrals.
4. Analyze, interpret, and evaluate scientific hypotheses and theories using rigorous statistical methods.

TEXT BOOKS:

1. B.V. Ramana "Higher Engineering Mathematics" Tata Mc Graw-Hill, 2006
2. B.S. Grewal – "Higher Engineering Mathematics", Khanna Publishers, 42nd Edition, 2013.

REFERENCE BOOKS

1. N P. Bali and Manish Goyal, "A text book of Engineering mathematics", Laxmi publications, latest edition.
2. Kreyszig, "Advanced Engineering Mathematics" - 9th edition, Wiley, 2013.
3. H. K Dass and Rajnish Verma,"Higher Engineering Mathematics", S. Chand publishing, 1st edition, 2011.

Aerodynamics-I

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**17AE42**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the basics of fluid mechanics as a prerequisite to Aerodynamics
2. Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and

study the incompressible over finite wings
3. Assimilate the understanding of application of finite wing theory and high lift systems

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Review of Basic Fluid Mechanics** Continuity, momentum and energy equation, Control volume approach to Continuity, momentum and energy equation, Types of flow, pathlines, streamlines, and streaklines, units and dimensions, inviscid and viscous flows, compressibility, Mach number regimes. Vorticity, Angular velocity, Stream function, velocity potential function, Circulation, Numericals, Mach cone and Mach angle, Speed of sound.	**10 Hours**	**L1, L2**
Module -2 **Airfoil Characteristics** Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, centre of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. Types of drag-Definitions.	**10 Hours**	**L1, L2**

Module -3 **Two Dimensional Flows & Incompressible Flow Over Airfoil** Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink. Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow. Lifting flow over a circular cylinder. Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, Numericals, **Incompressible flow over airfoils:** Kelvin's circulation theorem and the starting vortex, vortex sheet, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils. Kutta-Joukowski theorem and generation of Lift, Numericals.	**10 Hours**	**L1, L2, L3, L4, L5**
Module -4 **Incompressible Flow Over Finite Wings** Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortex filament, Induced velocity. Prandtl's classical lifting line theory: Downwash and induced drag. Elliptical and modified elliptical lift distribution. Lift distribution on wings. Limitations of Prandtl's lifting line theory. Extended lifting line theory-lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane.	**10 Hours**	**L1, L2**
Module -5 **Applications of Finite Wing Theory & High Lift Systems** Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. critical Mach numbers, Lift and drag divergence, shock induced separation, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects. Introduction to Source panel & vortex latice method.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
2. Compute and analyse the incompressible flow over finite wings
3. Apply finite wing theory and design high lift systems from the aerodynamics view point

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Anderson J.D, "Fundamental of Aerodynamics", 5th edition, McGraw-Hill International Edition, New York (2011), ISBN-13: 978-0073398105.
2. E. L. Houghton, P.W. Carpenter, "Aerodynamics for Engineering Students", 5th edition, Elsevier, New York. (2010), ISBN-13: 978-0080966328

Reference Books:

1. Clancy L. J. "Aerodynamics", Sterling book house, New Delhi. (2006), ISBN 13: 9780582988804
2. Louis M. Milne-Thomson, "Theoretical Aerodynamics", Imported Edition, Dover Publications, USA (2011), ISBN 9780486619804.

Aircraft Propulsion

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**17AE43**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the basic principle and theory of aircraft propulsion.
2. Understand the purpose of a centrifugal, axial compressors, axial and radial turbines
3. Acquire knowledge of importance of nozzles & inlets and combustion chamber

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles of internal combustion engine, Two – stroke and four – stroke piston engines, Gas- turbine engines, Cycle analysis of reciprocating engines and jet engines , advantages and disadvantages.	**10 Hours**	**L1, L2**
Module -2 **Propeller Theories & Jet propulsion** Types of propeller, Propeller thrust: momentum theory, Blade element theories, propeller blade design, propeller selection. **Jet Propulsion:** Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet – Performance characteristics.	**10 Hours**	**L1, L2, L3, L4**
Module -3 **Inlets & Nozzles** Internal flow and Stall in Subsonic inlets, Boundary layer separation. Major features of external flow near a subsonic inlet. Relation between minimum area ratio and eternal deceleration ratio. Diffuser performance. **Supersonic inlets:** Supersonic inlets, starting problem in supersonic inlets, Shock swallowing by area variation, External deceleration. Modes of inlet operation. **Nozzles:** Theory of flow in isentropic nozzles, Convergent nozzles and nozzle choking, Nozzle throat conditions. Nozzle efficiency, Losses in nozzles. Over-expanded and under-expanded nozzles, Ejector and variable area nozzles, Thrust reversal.	**10 Hours**	**L1, L2**
Module -4 **Gas Turbine Engine Compressors** **Centrifugal compressors:** Principle of operation of centrifugal compressors. Work done and pressure rise -Velocity diagrams, Diffuser vane design considerations. performance characteristics. Concept of Pre-whirl, Rotating stall. **Axial flow compressors:** Elementary theory of axial flow compressor, Velocity triangles, Degree of reaction, three dimensional flow. Air angle distribution for free vortex and constant reaction designs, Compressor blade design. Axial compressor performance characteristics.	**10 Hours**	**L1, L2, L3, L4**
Module -5 **Combustion chambers and Turbines** Classification of combustion chambers, important factors affecting	**10 Hours**	**L1, L2, L3, L4**

combustion chamber design, Combustion process, Combustion chamber performance Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders

Axial Flow Turbines: Introduction, Turbine stage, Multi-staging of turbine, Exit flow conditions, Turbine cooling, Heat transfer in turbine cooling.
Radial turbine: Introduction, Thermodynamics of radial turbines, Losses and efficiency.

Course outcomes:
After studying this course, students will be able to:
1. Apply the basic principle and theory of aircraft propulsion.
2. Explain the functions of centrifugal, axial compressors, axial and radial turbines
3. Analyse the performance of nozzles & inlets and combustion chamber.

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Bhaskar Roy, "Aircraft propulsion", Elsevier (2011), ISBN-13: 9788131214213
2. V. Ganesan, "Gas Turbines", Tata McGraw-Hill, 2010, New Delhi, India, ISBN: 0070681929.

Reference Books:
1. Hill, P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 1999, ISBN-13: 978-0201146592.
2. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman, 1989, ISBN 13: 9780582236325.
3. Irwin E. Treager, "Gas Turbine Engine Technology" GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd. Print 2003, ISBN-13: 978-0028018287
4. S. M. Yahya, "Fundamentals of Compressible Flow with Aircraft and Rocket propulsion", 4th Edition, New Age International Publications, New Delhi 2014, ISBN 13: 9788122426687.

Mechanisms and Machine Theory

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**17AE44**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03

Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objectives: This course will enable students to

1. Understand the theory of mechanisms including velocity, acceleration and static force analysis.
2. Acquire knowledge of spur gears, gear train, balancing of rotating and reciprocating masses.
3. Understand the concept of governors and gyroscope

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction to Mechanisms:** Types of constrained motion, Link and its types, joints and its types, kinematic pair and its types, degrees of freedom, Grubler's criterion, Types of kinematic chains and inversions: Inversions of Four bar chain: Beam engine, coupling rod of a locomotive, Watt's indicator mechanism. Inversions of Single Slider Crank Chain: Pendulum pump or Bull engine, Oscillating cylinder engine, Rotary internal combustion engine, Crank and slotted lever quick return motion mechanism, Whitworth quick return motion mechanism. Inversions of Double Slider Crank Chain: Elliptical trammels, Scotch yoke mechanism, Oldham's coupling. Straight line motion mechanisms: Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism and Ratchet and Pawl mechanism, Ackerman steering gear mechanism.	**10 Hours**	**L1, L2**
Module -2 **Velocity, Acceleration and static force analysis of Mechanisms (Graphical Methods):** Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms by vector polygons. **Static force analysis:** Introduction: Static equilibrium, Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction.	**10 Hours**	**L1, L2, L3, L4**
Module -3 **Spur Gears and Gear Trains** **Spur Gears:** Gear terminology, law of gearing, Path of contact, Arc of contact, Contact ratio of spur gear, Interference in involute gears, Methods of avoiding interference. **Gear Trains:** Simple gear trains, Compound gear trains, Reverted gear trains, Epicyclic gear trains, Analysis of epicyclic gear train (Algebraic and tabular methods), torques in epicyclic trains.	**10 Hours**	**L1, L2, L3, L4**
Module -4 **Balancing of Rotating and Reciprocating Masses** **Balancing of Rotating Masses:** Balancing of Several Masses Rotating in the Same Plane, Balancing of Several Masses Rotating in Different Planes (only Graphical Methods). **Balancing of Reciprocating Masses:** Primary and Secondary	**10 Hours**	**L1, L2, L3, L4**

Unbalanced Forces of Reciprocating Masses, Partial Balancing of Unbalanced Primary Force in a Reciprocating Engine, Balancing of Primary and secondary Forces of Multi-cylinder In-line Engines, Balancing of Radial Engines (only Graphical Methods)		
Module -5 **Governors and Gyroscope** **Governors:** Types of governors; force analysis of Porter and Hartnell governors, Controlling force, stability, sensitiveness, isochronism, effort and power of Porter and Hartnell governors. **Gyroscopes:** Vectorial representation of angular motion, gyroscopic couple, effect of gyroscopic couple on plane disc and aeroplane	**10 Hours**	**L1, L2, L3, L4**

Course outcomes:
After studying this course, students will be able to:
1. Apply the theory of velocity, acceleration and static force analysis to design of mechanisms.
2. Design spur gears, gear train, balancing of rotating and reciprocating masses.
3. Apply governors and gyroscope

Graduate Attributes (as per NBA):
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. **Rattan S.S**, "Theory of Machines", Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd edition -2009, ISBN: 007014477X, 9780070144774.
2. **J.J. Uicker, G.R. Pennock, J.E. Shigley.** "Theory of Machines & Mechanisms", OXFORD 3rd Ed. 2009, ISBN-13: 978-0195371239

Reference Books:
1. **R. S. Khurmi, J.K. Gupta,** "Theory of Machines", Eurasia Publishing House, 2008, ISBN 13: 9788121925242.
2. **Robert L Norton,** "Design of Machinery" by McGraw Hill, 2001, **ISBN-13:** 978-0077421717.
3. Ambekar, "Mechanism and Machine theory", PHI Learning Pvt. Ltd., 2007, ISBN 13: 9788120331341

Aircraft Material Science

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – IV

Subject Code	**17AE45**	IA Marks	40
Number of Lecture	04	Exam Hours	03

Hours/Week			
Total Number of Lecture Hours	50	Exam Marks	60
CREDITS – 04			

Course objectives: This course will enable students to

1. Acquire knowledge on aircraft materials- metallic and non-metallic
2. Understand the properties of super alloys, ablative materials and high energy material.
3. Study material corrosion and prevention

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction to Aircraft Materials** General properties of materials, Definition of terms, Requirements of aircraft materials, Testing of aircraft materials, Inspection methods, Application and trends in usage in aircraft structures and engines, Selection of materials for use in aircraft. **Aircraft Metal Alloys** Aluminum alloys, Magnesium alloys, Titanium alloys, Plain carbon and Low carbon Steels, Corrosion and Heat resistant steels, Maraging steels, Copper alloys, Producibility and Surface treatments aspects for each of the above;	**10 Hours**	**L1, L2**
Module -2 **Super Alloys** General introduction to super alloys, Nickel based super alloys, Cobalt based super alloys, and Iron based super alloys, manufacturing processes associated with super alloys, Heat treatment and surface treatment of super alloys. **Composite Materials:** Definition and comparison of composites with conventional monolithic materials, Reinforcing fibers and Matrix materials, Fabrication of composites and quality control aspects, Carbon-Carbon Composites production, properties and applications, inter metallic matrix composites, ablative composites based on polymers, ceramic matrix, metal matrix composites based on aluminum, magnesium, titanium and nickel based composites for engines.	**10 Hours**	**L1, L2**
Module -3 **Polymers, Polymeric Materials & Plastics and Ceramics & Glass** Knowledge and identification of physical characteristics of commonly used polymeric material: plastics and its categories, properties and applications; commonly used ceramic, glass and transparent plastics, properties and applications, adhesives and sealants and their applications in aircraft.	**10 Hours**	**L1, L2**
Module -4 **Ablative Materials** Ablation process, ablative materials and applications in aerospace. **Aircraft Wood, Rubber, Fabrics & Dope and Paint:** Classification and properties of wood, Seasoning of wood, Aircraft woods, their	**10 Hours**	**L1, L2**

properties and applications, Joining processes for wood, Plywood; Characteristics and definition of terminologies pertaining to aircraft fabrics and their applications, Purpose of doping and commonly used dopes; Purpose of painting, Types of aircraft paints, Aircraft painting process.		
Module -5 **Corrosion and its Prevention** Knowledge of the various methods used for removal of corrosion from common aircraft metals and methods employed to prevent corrosion. **High Energy Materials:** Materials for rockets and missiles. Types of propellants and its general and desirable properties, insulating materials for cryogenic engines. Types of solid propellants: Mechanical characterization of solid propellants using uni-axial, strip-biaxial and tubular tests.	**10 Hours**	**L1, L2**

Course outcomes:

After studying this course, students will be able to:

1. Identify appropriate aircraft materials for a given application.
2. Explain the properties of super alloys, ablative materials and high energy material.
3. Understand material corrosion process and apply prevention technique.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Titterton G F** , "Aircraft Material and Processes", English Book Store, New Delhi, 1998, ISBN 13: 9788175980136
2. **H Buhl**, "Advanced Aerospace Material", Spring Berlin 1992, ISBN: 978-3-642-50161-6

Reference Books:

1. **C G Krishnadas Nair,** "Handbook of Aircraft materials", Interline publishers, Bangalore, 1993, ISBN 13: 9788172960032.
2. **Balram Gupta, S**, "Aerospace material" Vol. 1,2,3 ARDB, Chand & Co 1996, ISBN: 9788121922005
3. **Parker E R**, "Materials for Missiles and Space", John Wiley, McGraw-Hill, 1963,
4. **Hill E T**, The "Materials of Aircraft Construction", Pitman London.

Turbomachines

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**17AE46**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03

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Total Number of Lecture Hours	40	Exam Marks	60
CREDITS – 03			

Course objectives: This course will enable students to

1. Understand the basics of turbomachines, the energy transfer and energy transformation in them.
2. Acquire the knowledge on design of centrifugal and axial turbomachines
3. Study hydraulic pumps and turbines

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction to turbomachines:** Classification and parts of a turbo machines; comparison with positive displacement machines; dimensionless parameters and their physical significance; specific speed; illustrative examples on dimensional analysis and model studies. **Energy transfer in turbomachines:** Basic Euler turbine equation and its alternate form; components of energy transfer; general expression for degree of reaction; construction of velocity triangles for different values of degree of reaction.	**10 Hours**	**L1, L2**
Module -2 **Compression process:** Overall isentropic efficiency of compression; stage efficiency; comparison and relation between overall efficiency and stage efficiency; polytropic efficiency; pre heat factor. **Expansion process:** Overall isentropic efficiency for a turbine; stage efficiency for a turbine; comparison and relation between stage efficiency and overall efficiency, polytropic efficiency; reheat factor for expansion process.	**10 Hours**	**L1, L2, L3, L4**
Module -3 **Design and performance analysis of Centrifugal compressors:** Types, design parameters, flow analysis in impeller blades, volutes and diffusers, losses, slip factor, characteristic curves, surging, choking. Construction details. **Design and performance analysis of axial fans and compressors:** Stage velocity diagrams, enthalpy-entropy diagrams, stage losses and efficiency, work done, simple stage design problems, performance characteristics, instability in axial compressors. Construction details.	**10 Hours**	**L1, L2, L3, L4**
Module -4 **Design and performance analysis of axial flow turbines:** Turbine stage, work done, degree of reaction, losses and efficiency, flow passage; subsonic, transonic and supersonic turbines, multi-staging of turbine; exit flow conditions; turbine cooling **Design and performance analysis of radial turbines:** Thermodynamics and aerodynamics of radial turbines; radial turbine characteristics; losses and efficiency; design of radial turbine.	**10 Hours**	**L1, L2, L3, L4**

Module -5	10 Hours	L1, L2, L3, L4, L5
Hydraulic pumps: Centrifugal and axial pumps. Manometric head, suction head, delivery head; manometric efficiency, hydraulic efficiency, volumetric efficiency, overall efficiency; multi stage pumps. Characteristics of pumps. **Hydraulic turbines:** Classification; Module quantities; Pelton wheel, Francis turbine, Kaplan turbine and their velocity triangles. Draft tubes and their function. Characteristics of hydraulic turbines.		

Course outcomes:

After studying this course, students will be able to:

1. Compute the energy transfer and energy transformation in turbomachines.
2. Analyse the design of turbomachine blades.
3. Apply hydraulic pumps and turbines for specific requirements

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. S.M. Yahya, “Turbines, Compressors & Fans”, Tata-McGraw Hill Co., 2nd Edition (2002), ISBN 13: 9780070707023.
2. D.G. Shephered, “Principles of Turbo Machinery”, The Macmillan Company (1964), ISBN-13: 978-0024096609.

Reference Books:

1. V. Kadambi and Manohar Prasad, “An introduction to Energy conversion, Volume III, Turbo machinery “, Wiley Eastern Ltd, 1977, ISBN: 9780852264539

MATERIAL TESTING LAB

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – IV

Subject Code	**17AEL47A**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course objectives: This course will enable students to
1. Understand the relations among materials and their properties.
2. Understand the formation, properties and significance of the alloys through different experiments.
3. Understand the types, advantages and applications of various NDT methods.

MODULES **PART-A: MATERIAL TESTING**	**Revised Bloom's Taxonomy (RBT) Level**
1. Hardness Testing – Vicker's, Brinell, Rockwell	**L1, L2, L3**
2. Tensile Test	**L1, L2, L3, L4, L5**
3. Flexural Test	**L1, L2, L3, L4, L5**
4. Tensional Test	**L1, L2, L3**
5. Impact Test	**L1, L2, L3**
6. Shear Test	**L1, L2, L3**
7. Fatigue Test	**L1, L2, L3, L4, L5**
PART-B: METALLOGRAPHY	
8. Preparation of specimen for metallographic examination of different engineering materials. Identification of microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & metal matrix composites	**L1, L2, L3**
9. Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-treated samples.	**L1, L2, L3**
10. To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.	**L1, L2, L3**
11. Visual Testing Technique, Dye penetration testing. To study the defects of Cast and Welded specimens.	**L1, L2, L3**
12. Magnetic Particle Inspection.	**L1, L2, L3**
13. Ultrasonic Inspection.	**L1, L2, L3**
14. Eddy Current Inspection	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Apply the relations among materials and their properties.
2. Differentiate the formation, properties and significance of the alloys through different experiments.
3. Understand the different types, advantages and applications of various NDT methods

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Scheme of Examination:

One question from PART A:	**1 x 30 =**	**30 Marks**
One question from PART B:	**1 x 40 =**	**40 Marks**
Viva-Voce :		**10 Marks**
	Total =	**80 Marks**

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

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MEASUREMENTS AND METROLOGY LAB

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – IV

Subject Code	**17AEL47B**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course objectives: This course will enable students to

1. Learn the concepts of mechanical measurements and metrology
2. Use the concept of accuracy, error and calibration
3. Use the basic metrological instruments

Modules	Revised Bloom's Taxonomy (RBT) Level
PART-A: MEASUREMENTS	
1. Calibration of Pressure Gauge	**L1, L2, L3, L4**
2. Calibration of Thermocouple	**L1, L2, L3, L4**
3. Calibration of LVDT	**L1, L2, L3, L4**
4. Calibration of Load cell	**L1, L2, L3, L4**
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.	**L1, L2, L3, L4, L5**
PART-B: METROLOGY	
6. Comparison and measurements using vernier caliper and micrometer	**L1, L2, L3, L4**
7. Measurement of vibration parameters using vibration setup.	**L1, L2, L3, L4**
8. Measurements using Optical Projector / Toolmaker Microscope.	**L1, L2, L3**
9. Measurement of angle using Sine Center / Sine bar / bevel protractor	**L1, L2, L3**
10. Measurement of alignment using Autocollimator / Roller set	**L1, L2, L3**
11. Measurement of Screw thread Parameters using Two-wire or Three-wire method.	**L1, L2, L3**
12. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator	**L1, L2, L3**
13. Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer	**L1, L2, L3**
14. Calibration of Micrometer using slip gauges	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Identify and classify different measuring tools related to experiments.
2. Identify, define, and explain accuracy, resolution, precision, and some additional terminology.
3. Conduct, Analyze, interpret, and present measurement data from measurements experiments.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.

2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Scheme of Examination:

One question from PART A: **1 x 30 = 30 Marks**

One question from PART B: **1 x 40 = 40 Marks**

Viva-Voce : 10 Marks

Total = 80 Marks

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

COMPUTER AIDED AIRCRAFT DRAWING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – IV

Subject Code	**17AEL48**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course objectives: This course will enable students to

1. Understand and interpret drawings of machine and aircraft components
2. Prepare assembly drawings either manually or by using standard CAD packages.
3. Familiarize with standard components and their assembly of an aircraft.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
PART A	
1. Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections.	**L1, L2, L3, L6**
2. **Orthographic Views:** Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings) Hidden line conventions. Precedence of lines.	**L1, L2, L3**
PART B	

3.Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External) BSW (Internal & External) square and Acme. Sellers thread, American Standard thread.	**L1, L2, L3**
4.Fasteners: Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw.	**L1, L2, L3**
5.Keys & Joints: Parallel key, Taper key, Feather key, Gibhead key and Woodruff key	**L1, L2, L3**
6.Riveted Joints: Single and double riveted lap joints, butt joints with single/double cover straps (Chain and Zigzag, using snap head rivets). Cotter joint (socket and spigot), knuckle joint (pin joint) for two rods.	**L1, L2, L3**
7. Couplings: Split Muff coupling, protected type flanged coupling, pin (bush) type flexible coupling, Oldham's coupling and universal coupling (Hooks' Joint)	**L1, L2, L3**
PART C	
8. Design of propeller and hub assembly	**L1, L2, L3**
9. Design of wing assembly	**L1, L2, L3**
10. Design of fuselage assembly	**L1, L2, L3**
11. Design of Engine Mounts	**L1, L2, L3**
12. Design of main rotor blade assembly of helicopter	**L1, L2, L3, L4, L5, L6**
13. Design of UAV assembly	**L1, L2, L3, L4, L5, L6**
14. Design of Landing Gear Assembly	**L1, L2, L3, L4, L5, L6**

Course outcomes:
After studying this course, students will be able to:
1. Distinguish drawings of machine and aircraft components
2. Identify assembly drawings either manually or by using standard CAD packages.
3. Practice with standard components and their assembly of an aircraft.

Conduct of Practical Examination:
Internal Assessment: 20 Marks

Sketches shall be in sketch books and drawing shall be drawn through the use of software on A3/A4 sheets. Sketch book and all the drawing printouts shall be submitted.

Scheme of Evaluation for Internal Assessment (20 Marks)

(a) Class work (Sketching and Computer Aided Aircraft Drawing printouts in A4/A3 size sheets): 10Marks.

(b) Internal Assessment test in the same pattern as that of the main examination (Better of the two Tests): 10 marks.

Scheme of Examination:

Two questions are to be set from each Part-A, Part-B and Part-C.

Student has to answer one question each from Part A and Part B for 15 marks each and one question from Part C for 50 marks.

i.e. **Part A 1 x 15 = 15 Marks**

Part B 1 x 15 = 15 Marks

Part C 1 x 50 = 50 Marks

Total = 80 Marks

INSTRUCTION FOR COMPUTER AIDED AIRCRAFT DRAWING (**17AEL48**) EXAMINATION

1. There is no restriction of timing for sketching/ computerization of solutions. The total duration is 3 hours.

2. It is desirable to do sketching of all the solutions before computerization.

3. Drawing instruments may be used for sketching.

4. For Part A and Part B 2D drafting environment should be used.

5. For Part C 3D part environment should be used for parts assembly drawing and extract 2D views.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

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B.E. AERONAUTICAL ENGINEERING

V SEMESTER

Sl. No	Subject Code	Title .	Teaching Hours /Week		Examination				Credits
			Theory	Practical/Drawing	Duration	Theory / Practical Marks	I.A. Marks	Total Marks	
1	17AE51	MANAGEMENT AND ENTREPRENEURSHIP	04		03	60	40	100	4
2	17AE52	INTRODUCTION TO COMPOSITE MATERIALS	04		03	60	40	100	4
3	17AE53	HEAT AND MASS TRANSFER	04		03	60	40	100	4
4	17AE54	AIRCRAFT STRUCTURES-I	04		03	60	40	100	4
5	17AE55X	PROFESSIONAL ELECTIVE	03		03	60	40	100	3
6	17AEL56X	OPEN ELECTIVE	03		03	60	40	100	3
7	17AEL57	AERODYNAMICS LAB		1I+2P	03	60	40	100	2
8	17AEL58	ENERGY CONVERSION & FLUID MECHANICS LAB		1I+2P	03	60	40	100	2
TOTAL			**22**	**06**	**24**	**480**	**320**	**800**	**26**

Professional Elective		Open Elective	
17AE551	FUELS & COMBUSTION	17AE561	HISTORY OF FLIGHT & TECHNOLOGY FORECAST
17AE552	GAS DYNAMICS	17AE562	ELEMENTS OF AERONAUTICS
17AE553	THEORY OF VIBRATIONS	17AE563	AIRCRAFT TRANSPORTATION SYSTEMS
17AE554	AIRCRAFT ELECTRICAL SYSTEMS & INSTRUMENTATION	17AE564	BASICS OF ROCKETS AND MISSILES

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Elective relevant to chosen specialization/ branch
3. **Open Elective**: Electives from other technical and/or emerging subject areas.

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MANAGEMENT AND ENTREPRENEURSHIP
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V

Subject Code	**17AE51**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives:
This course will enable students to
1. Understand the basic concepts of management, planning, organizing and staffing.
2. Acquire the knowledge to become entrepreneur.
3. Comprehend the requirements towards the small-scale industries and project preparation.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Management:** Definition, Importance – Nature and Characteristics of Management, Management Functions, Roles of Manager, Levels of Management, Managerial Skills, Management & Administration, Management as a Science, Art & Profession **Planning:** Nature, Importance and Purpose Of Planning, Types of Plans, Steps in Planning, Limitations of Planning, Decision Making – Meaning, Types of Decisions- Steps in Decision Making.	**10 Hours**	**L1, L2, L3**
Module -2 **Organizing and Staffing:** Meaning, Nature and Characteristics of Organization – Process of Organization, Principles of Organization, Departmentalisation, Committees –meaning, Types of Committees, Centralization Vs Decentralization of Authority and Responsibility, Span of Control (Definition only), Nature and Importance of Staffing, Process of Selection and Recruitment. **Directing and Controlling:** Meaning and Nature of Directing-Leadership Styles, Motivation Theories Communication – Meaning and Importance, Coordination- Meaning and Importance, Techniques of Coordination. Controlling – Meaning, Steps in Controlling.	**10 Hours**	**L1, L2,L3**
Module -3 **Social Responsibilities of Business:** Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance. **Entrepreneurship**: Definition of Entrepreneur, Importance of Entrepreneurship, concepts of Entrepreneurship, Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Intrapreneur – An Emerging Class, Comparison between Entrepreneur and Intrapreneur, Myths of Entrepreneurship, Entrepreneurial Development	**10 Hours**	**L2, L3, L4**

models, Entrepreneurial development cycle, Problems faced by Entrepreneurs and capacity building for Entrepreneurship.		
Module -4 **Modern Small Business Enterprises:** Role of Small Scale Industries, Concepts and definitions of SSI Enterprises, Government policy and development of the Small Scale sector in India, Growth and Performance of Small Scale Industries in India, Sickness in SSI sector, Problems for Small Scale Industries, Impact of Globalization on SSI, Impact of WTO/GATT on SSIs, Ancillary Industry and Tiny Industry (Definition only). **Institutional Support for Business Enterprises:** Introduction, Policies & Schemes of Central–Level Institutions, State-Level Institutions.	**10 Hours**	**L3,L4,L5**
Module -5 **Project Management:** Meaning of Project, Project Objectives & Characteristics, Project Identification- Meaning & Importance; Project Life Cycle, Project Scheduling, Capital Budgeting, Generating an Investment Project Proposal, Project Report-Need and Significance of Report, Contents, Formulation, Project Analysis-Market, Technical, Financial, Economic, Ecological, Project Evaluation and Selection, Project Financing, Project Implementation Phase, Human & Administrative aspects of Project Management, Prerequisites for Successful Project Implementation. New Control Techniques- PERT and CPM, Steps involved in developing the network, Uses and Limitations of PERT and CPM	**10 Hours**	**L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Explain about the management and planning.
2. Apply the knowledge on planning, organizing, staffing, directing and controlling.
3. Describe the requirements towards the small-scale industries and project preparation.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Modern Tool Usage and Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Principles of Management–P.C.Tripathi, P.N.Reddy –Tata Mc Graw Hill,
2. Dynamics of Entrepreneurial Development & Management Vasant Desai-Himalaya Publishing House
3. Entrepreneurship Development – Poornima. M. Charantimath Small Business Enterprises-Pearson Education-2006.

Reference Books:

1. Management Fundamentals- Concepts, Application, Skill Development-Robers Lusier-Thomson
2. Entrepreneurship Development - S.S. Khanka- S. Chand & Co.
3. Management-Stephen Robbins-Pearson Education/PHI-17th Edition,2003.

INTRODUCTION TO COMPOSITE MATERIALS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	**17AE52**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives:
This course will enable students to

1. Understand the advantages of composite materials compared to conventional materials
2. Evaluate the properties of polymer matrix composites with fiber reinforcements
3. Explain the manufacturing process and applications of composite materials

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction to Composite Materials** Definition, classification of composite materials, classification of reinforcement - particulate, short fiber, whiskers, long fibers composites. matrix materials – metals, ceramics, polymers (including thermoplastics and thermosets), Carbon-Carbon Composites **Metal Matrix Composites:** MMC with particulate and short fiber reinforcement, liquid and solid state processing of MMC – stir casting, squeeze casting. Properties of MMCs, Applications of Al, Mg, Ti based MMC	**8 Hours**	**L1, L2, L3**
Module -2 **Processing of Polymer Matrix Composites:** Thermoset Polymers, Hand layup Process, Vacuum Bagging Process, Post Curing Process, Filament winding, Pultrusion, Pulforming, Autoclave Process **Processing of Polymer Matrix Composites:** Thermoplastic Polymers, Extrusion process, Injection Moulding Process, Thermo-forming process. **Post Processing of Composites –** Adhesive bonding, drilling, cutting processes.	**10 Hours**	**L1, L2,L3**
Module -3 **Micro-Mechanical Behavior of a Lamina** Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants. **Macro-Mechanical Behavior of a Lamina:** Global and local axis for angle lamina, determination of global and local stresses and moduli, for 2D-UD lamina with different fiber orientation	**12 Hours**	**L2, L3, L4**

and different fiber materials glass, carbon and aramid fiber reinforcement.		
Module -4 **Failure Theory** – Tsai-Hill, Tsai-Wu, Max Stress and Max Strain Classical plate theory- Stress and strain variation in a laminate- Resultant forces and moments- A B & D matrices- Strength analysis of a laminate.	**10 Hours**	**L3,L4,L5**
Module -5 **Inspection & Quality Control**: Destructive & Non-Destructive Testing, Tensile, Compression, Flexural, Shear, Hardness; ultrasonic testing – A-B-C scan **Applications of Composites Materials** Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.	**10 Hours**	**L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Explain the advantages of using composite materials as an alternative to conventional materials for specific applications
2. Describe the advanced fabrication and processing for producing composite parts.
3. Evaluate the micro- and macro-mechanical behavior of composite laminates

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Modern Tool Usage and Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **K.K Chawla**, Composite Materials- Science and Engineering, II edition, Springer Verlag, 1998: ISBN: 0-387-98409-7
2. **Autar Kaw**, Mechanics of Composites, II edition, CRC Press. 2006, ISBN:978-0-8493-1343-1

Reference Books:

1. **Mein Schwartz,** Composite Materials Handbook, Vol.3, Department of Defense, USA, 2002.
2. **Ajay Kapadia,** Non-Destructive Testing of Composite Materials, National Composites Network, Best Practices Guide, TWI Publications, 2006.
3. **R M Jones,** " Mechanics of Composite Materials", 2^{nd}Edn, Taylor & Francis, 2015; ISBN:978-1560327127

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HEAT & MASS TRANSFER

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	**17AE53**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the different modes of heat transfer.
2. Understand the free convection and forced convection.
3. Acquire the knowledge of heat transfer problems in combustion chambers.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Fundamentals:** Different modes of heat transfer and mass and momentum transfer, elements of mass diffusion and boundary layer theory. Mass transfer definition and terms used in mass transfer analysis, Fick's First law of diffusion (no numerical).	**10 Hours**	**L1, L2**
Module -2 **Conduction:** Derivation of general three dimensional conduction equation in Cartesian coordinate, special cases, discussion on 3-D conduction in cylindrical and spherical coordinate systems. Effect of variation of thermal conductivity on heat transfer in solids - Heat transfer problems in infinite and semi-infinite solids - Extended surfaces. One dimensional transient heat conduction: Systems with negligible internal resistance, Significance of Biot and Fourier Numbers, Chart solutions of transient conduction systems.	**10 Hours**	**L1, L2**
Module -3 **Convection:** Concepts of Continuity, Momentum and Energy Equations. Dimensional analysis-Buckingham's Pi Theorem - Application for developing non-dimensional correlation for convective heat transfer **Free Convection:** Development of Hydrodynamic and thermal boundary layer along a vertical plate , Use of empirical relations for Vertical plates and pipes. **Forced Convection:** External Flows, Concepts of hydrodynamic and thermal boundary layer and use of empirical correlations for Flat plates and Cylinders. Internal Flows, Concepts about Hydrodynamic and Thermal Entry Lengths, use of empirical correlations for Horizontal Pipe Flow and annulus flow.	**10 Hours**	**L1, L2, L3**

Module -4 **Radiation & Heat Exchangers Design: Radiation:** Introduction to physical mechanism - Radiation properties - Radiation shape factors - Heat exchange between non-black bodies - Radiation shields **Heat Exchangers:** Classification of heat exchangers; overall heat transfer coefficient, fouling and fouling factor; LMTD, Effectiveness-NTU methods of analysis of heat exchangers. Numerical problems.	**10 Hours**	**L1, L2, L3**
Module -5 **Heat and Mass Transfer Problems in Aerospace Engineering:** Heat transfer problems in gas turbine combustion chambers - Rocket thrust chambers - Aerodynamic heating -Ablative heat transfer. **Mass Transfer:** Introduction, Ficks law, Species conservation equation, Introduction to convective and diffusive mass transfer.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Describe the fundamental of heat and mass transfer.
2. Familiarize the student in the area of conduction, convection and radiation.
3. Analyze the problems due to heat transfer in several areas.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Ozisik, Heat transfer-A basic approach, Tata McGraw Hill 2002
2. Holman, J.P., " Heat Transfer ", McGraw Hill Book Co., Inc., New York, 8th edition., 1996, ISBN-13: 978-0071143202

Reference Books:

1. Sachdeva, S.C., " Fundamentals of Engineering Heat and Mass Transfer “, Wiley Eastern Ltd., New Delhi, 1981.
2. Sutton, G.P., “Rocket Propulsion Elements ", John Wiley and Sons, 5th Edn.1986.
3. Mathur, M.and Sharma, R.P., " Gas Turbine and Jet and Rocket Propulsion “, Standard Publishers, New Delhi 1988.
4. P.K. Nag, Heat transfer, Tata McGraw Hill 2002
5. Yunus A- Cengel , Heat transfer, a practical approach, Tata McGraw Hill , 3rd edition, 2007.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

AIRCRAFT STRUCTURES - I

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	**17AE54**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Comprehend the basic concepts of stress and strain.
2. Acquire the knowledge of types of loads on aerospace vehicles.
3. Understand the theory of elasticity.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Design for Static Strength** Introduction: Normal, shear, biaxial and tri-axial stresses, Stress tensor, Principal Stresses, Stress Analysis, Design considerations, Codes and Standards. Static Strength: Static loads and factor of safety, Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Maximum strain theory, Strain energy theory, and Distortion energy theory, failure of brittle and ductile materials, Stress concentration, and Determination of Stress concentration factor.	**10 Hours**	**L1, L2**
Module -2 **Design for Impact and Fatigue Strength** Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Introduction, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.	**10 Hours**	**L1, L2**
Module -3 **Loads on Aircraft and Aircraft Materials** **Loads on Aircraft**: Structural nomenclature, Types of loads, load factor, Aerodynamics loads, Symmetric manoeuvre loads, Velocity diagram, Function of structural components. **Aircraft Materials:** Metallic and non-metallic materials, Use of Aluminum alloy, titanium, stainless steel and composite materials.	**10 Hours**	**L1, L2, L3**

Desirable properties for aircraft application. Fracture and Fatigue, Stress Intensity Factor, Crack Growth Rate Derivation.		
Module -4 **Theory of Elasticity and Structures:** **Theory of Elasticity: and** Theory of Elasticity: Concept of stress and strain, derivation of Equilibrium equations, strain displacement relation, compatibility conditions and boundary conditions. Plane stress and Plane strain problems in 2D elasticity. Principle Stresses and Orientation of Principle Directions. **Structures:** Statically Determinate and Indeterminate structures, Analysis of plane truss, Method of joints, 3D Truss, Plane frames, Composite beam, Clapeyron's Three Moment Equation.	**10 Hours**	**L1, L2, L3**
Module -5 **Energy Methods and Columns** **Energy Methods:** Strain Energy due to axial, bending and Torsional loads. Castigliano's theorem, Maxwell's Reciprocal theorem. **Columns**: Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, south-well plot, Beam-column.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

4. Apply the basic concepts of stress and strain analysis.
5. Compute the impact stress.
6. Identify appropriate materials for suitable application based on properties.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **V.B. Bhandari,** 'Design of Machine Elements', Tata McGraw Hill Publishing Company Ltd., New Delhi, 2nd Edition 2007.

2. **Megson, T.M.G** ‘Aircraft Structures for Engineering Students’,., Edward Arnold, 1995.
3. **Timoshenko and Goodier,”** ‘Theory of Elasticity’, McGraw Hill Co.

Reference Books:

1. **Robert L. Norton ,** Machine Design, , Pearson Education Asia, 2001.
2. **Donaldson, B.K.,** “Analysis of Aircraft Structures – An Introduction”, McGraw-Hill, 1993.
3. **Timoshenko, S.,** “Strength of Materials”, Vol. I and II, Princeton D Von Nostrand Co, 1990
4. **Joseph E Shigley and Charles R.Mischke**, Mechanical Engineering Design, McGraw Hill International edition, 6th Edition 2009.
5. **Peery, D.J., and Azar, J.J.,** “Aircraft Structures”, 2nd edition, McGraw, Hill, N.Y., 1993.
6. **Bruhn. E.H.** “Analysis and Design of Flight Vehicles Structures”, Tri – state off set company, USA, 1985.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Professional Elective

FUELS & COMBUSTION

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V
Professional Elective

Subject Code	**17AE551**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the basic properties of fuel.
2. Acquire the knowledge of fuel treatment.
3. Understand the combustion fundamentals and performance.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Fuel Properties:** Fuel Properties, Relative Density, API Gravity, Molecular Mass, Distillation Range, Vapor Pressure, Flash Point, Volatility Point, Viscosity, Surface Tension, Freezing Point, Specific Heat, Latent Heat, Thermal Conductivity, Combustion Properties of Fuels, Calorific Value, Enthalpy, Spontaneous-Ignition temperature, Limits of Flammability, Smoke Point, Luminometer Number, Smoke Volatility Index, Pressure and Temperature Effects, Sub atmospheric Pressure, Low Temperature, High Temperature.	**6 Hours**	**L1, L2**
Module -2 **Fuel Treatment:** Introduction, Types of Hydrocarbons, Paraffins, Olefins, Naphthenes, Aromatics, Production of Liquid Fuels, Removal of Sulfur Compounds, Contaminants, Asphaltenes, Gum, Sediment, Ash, Water, Sodium, Vanadium, Additives, Gum Prevention, Corrosion Inhibition/Lubricity Improvers, Anti-Icing, Antistatic–Static Dissipators, Metal Deactivators, Antismoke.	**6 Hours**	**L1, L2**
Module -3 **Alternative Fuels aerospace applications:** Hydrogen, Methane, Propane, Ammonia, Alcohols, Slurry fuels, Synthetic fuels, Fuels Produced by Fischer–Tropsch Synthesis of Coal/Biomass, Biofuels, Alternative fuel Properties, Combustion and Emissions Performance, Fischer–Tropsch Fuels, Biodiesel Fuels, Highly Aromatic (Broad Specification)	**8 Hours**	**L1, L2, L3**

Basic Considerations**:** Introduction to Gas turbine Combustor, Basic Design Features, Combustor Requirements, Combustor Types and parts, Fuel Preparation, Atomizers, liner wall-cooling Techniques, combustor stability limits, combustor exit temperature traverse quality (pattern factors), Combustors for Low Emissions.		
Module -4 **Combustion Fundamentals:** Deflagration, Detonation, Classification of Flames, Physics of combustion Chemistry, Flammability Limits, Global Reaction-Rate Theory, Weak Mixtures, Rich Mixtures, Laminar Premixed Flames, laminar and turbulent flame burning velocity, measurement techniques for flame velocity, Factors Influencing Laminar Flame Speed, Equivalence Ratio, Initial Temperature, Pressure, Laminar Diffusion Flames, Turbulent Premixed Flames, Flame Propagation in Heterogeneous Mixtures of Fuel Drops, Fuel Vapor and Air. Combustion flame characterization: Droplet and Spray Evaporation, Heat-Up Period, Evaporation Constant, Convective Effects, Effective Evaporation Constant, Spray Evaporation, Ignition Theory, Gaseous Mixtures, Heterogeneous Mixtures, Spontaneous Ignition, Flashback, Stoichiometry, Adiabatic Flame Temperature, Factors Influencing the Adiabatic Flame Temperature, Fuel/Air Ratio, Initial Air Temperature, Pressure.	**10 Hours**	**L1, L2, L3**
Module -5 **Combustion Performance:** Combustion Efficiency, The Combustion Process, Reaction-Controlled Systems, Burning Velocity Model, Stirred Reactor Model, Mixing-Controlled Systems, Evaporation-Controlled Systems, Reaction- and Evaporation-Controlled Systems. Flame Stabilization & Fuel Classification: Definition of Stability Performance, Measurement of Stability Performance, Bluff-Body Flame holders, Stabilization, Mechanisms of Flame Stabilization, Flame Stabilization in Combustion Chambers, Classification of Liquid Fuels, Aircraft Gas Turbine Fuels, Engine Fuel System, Aircraft Fuel Specifications, Classification of Gaseous Fuels.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Explain the fuel properties and fuel treatment process.
2. Select the alternative fuels for aerospace applications.
3. Compute the combustion performance.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Arthur H. Lefebvre & Dilip R. Ballal, Gas Turbine Combustion, CRC Press, 3rd Edition, 2010
2. Minkoff, G.J., and C.F.H. Tipper, Chemistry of Combustion Reaction, London Butterworths, 1962.
3. Samir Sarkar, Fuels & Combustion, Orient Long man 1996.

Reference Books:

1. Wilson, P.J. and J.H. Wells, Coal, Coke and Coal Chemicals, McGraw-Hill, 1960.
2. Williams, D.A. and G. James, Liquid Fuels, London Pergamon, 1963.
3. Gas Engineers Handbook, New York, Industrial Press, 1966.

GAS DYNAMICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V

Professional Elective

Subject Code	**17AE552**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the fundamentals of steady, isentropic and adiabatic flow.
2. Acquire the knowledge of wave phenomena.
3. Understand the concepts of flames and combustion.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**

Module -1 **Fundamental Equations of Steady Flow:** Continuity and momentum equations, The thrust function, The dynamic equation and Euler's Equation. Bernoulli's Equation. Steady flow energy equation.	**6 Hours**	**L1, L2**
Isentropic Flow: Acoustic velocity, Mach number, Mach cone and Mach angle. Flow parameters, stagnation temperature, pressure, and density. **Adiabatic Flow:** Stagnation temperature change. Rayleigh line, Pressure ratio and temperature ratio, Entropy considerations, maximum heat transfer **Flow with Friction:** The fanning equation, Friction factor and friction parameter, Fanno line, Fanno equations.	**10 Hours**	**L1, L2**
Module -3 **Wave Phenomena**: Classification of wave phenomena, analysis of shock phenomena, Hugoniot equation. Weak waves, compression waves, Normal shock waves, oblique shock waves, Entropy considerations, Rayleigh Pilot equations, detonation and deflageration.	**8 Hours**	**L1, L2, L3**
Module -4 **Variable Area Flow:** Velocity variation with Isentropic flow, Criteria for acceleration and deceleration. Effect of pressure ratio on Nozzle operation. Convergent nozzle and convergent divergent nozzle. Effect of back pressure on nozzle flow. Isothermal flow functions. Comparison of flow in nozzle. Generalized one dimensional flow.	**8 Hours**	**L1, L2, L3**
Module -5 **Applications of dimensional analysis** and similitude to gas dynamic problems. **Introduction to Flames and Combustion:** Flame propagation, diffusion flames, premixed flames, flame velocity, theories of flame propagation, ignition for combustible mixture, flame stabilization.	**8 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Apply the equations of steady flow.
2. Explain the isentropic flow, adiabatic flow and wave phenomena.
3. Describe the flames and combustion.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **Fundamentals of Compressible flow**: Yahya, 2nd Edn. 1991; Wiley Eastern.
2. **Gas Dynamics,** E Radhakrishnan, PHI-2006

Reference Books:

1. **Introduction to Gas Dynamics:** Rolty, Wiley 1998
2. **Elements of Gas Dynamics:** Liepmann and Roshko, Wiley 1994.
3. **The dynamics and thermodynamics of compressible fluid flow:** Shapiro Ronold Press. 1994.
4. **Modern Compressible Flow**, J. D. Anderson, McGraw Hill Education, 2004.

THEORY OF VIBRATIONS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V

Open Elective

Subject Code	**17AE553**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Understand the basic concepts of vibrations.
2. Understand the working principle of vibration measuring instruments.
3. Acquire the knowledge of numerical methods for multi-degree freedom systems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Types of vibrations, S.H.M, principle of super position applied to Simple Harmonic Motions. Beats, Fourier theorem and simple problems.	**4 Hours**	**L1, L2**

Module -2 **Undamped Free Vibrations:** Single degree of freedom systems. Undamped free vibration, natural frequency of free vibration, Spring and Mass elements, effect of mass of spring, Compound Pendulum. **Damped Free Vibrations:** Single degree of freedom systems, different types of damping, concept of critical damping and its importance, study of response of viscous damped systems for cases of under damping, critical and over damping, Logarithmic decrement.	**8 Hours**	**L1, L2**
Module -3 **Forced Vibration:** Single degree of freedom systems, steady state solution with viscous damping due to harmonic force. Solution by Complex algebra, reciprocating and rotating unbalance, vibration isolation, transmissibility ratio. due to harmonic exitation and support motion. **Vibration Measuring Instruments & Whirling of Shafts:** Vibration of elastic bodies – Vibration of strings – Longitudinal, lateral and torsional Vibrations.	**8 Hours**	**L1, L2, L3**
Module -4 **Systems with Two Degrees of Freedom:** Introduction, principle modes and Normal modes of vibration, co-ordinate coupling, generalized and principal co-ordinates, Free vibration in terms of initial conditions. Geared systems. Forced Oscillations-Harmonic excitation. Applications: a) Vehicle suspension. b) Dynamic vibration absorber. c) Dynamics of reciprocating Engines. **Continuous Systems:** Introduction, vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler's equation for beams.	**10 Hours**	**L1, L2, L3**
Module -5 **Numerical Methods for Multi-Degree Freedom Systems:** Introduction, Influence coefficients, Maxwell reciprocal theorem, Dunkerley's equation. Orthogonality of principal modes, Method of matrix iteration-Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle. Holzer's method, Stodola method.	**10 Hours**	**L1, L2, L3**
Course Outcomes: After studying this course, students will be able to: 1. Apply the principle of super position to Simple Harmonic Motions. 2. Determine the vibrations using vibration instruments. 3. Apply the numerical methods for multi-degree freedom systems.		
Graduate Attributes: o Engineering Knowledge. o Problem Analysis. o Design / development of solutions o Interpretation of data		
Question paper pattern:		

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. W.T. Thomson and Marie Dillon Dahleh, Theory of Vibration with Applications, Pearson Education 5th edition, 2008,ISBN-13: 978-8131704820.
2. V.P. Singh ,Mechanical Vibrations, Dhanpat Rai& Company Pvt. Ltd.,2016,ISBN-13: 978-8177004014.

Reference Books:

1. S.S. Rao, Mechanical Vibrations, Pearson Education Inc, 4th Edition,2003,ISBN-13: 978-8177588743
2. S. Graham Kelly, Mechanical Vibrations- Schaum's Outline Series, Tata McGraw Hill, Special Indian edition, 2007.
3. J.S. Rao & K. Gupta, Theory & Practice of Mechanical vibrations, New Age International Publications, New Delhi, 2001.
4. Leonanrd Meirovitch, Elements of Vibrations Analysis, Tata McGraw Hill, Special Indian edition, 2007.

AIRCRAFT ELECTRICAL SYSTEMS & INSTRUMENTATION

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V

Professional Elective

Subject Code	**17AE554**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives:
This course will enable students to

1. Understand the aircraft control systems.
2. Understand the aircraft systems.
3. Acquire the knowledge of aircraft instruments.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Airplane Control Systems:** Conventional Systems, fully powered flight controls, Power actuated systems, Modern control systems, Digital fly by wire systems, Auto pilot system active control	**8 Hours**	**L1,L2**

Technology.		
Module -2 **Aircraft Systems:** Hydraulic systems, Study of typical workable system, components, Pneumatic systems, Advantages, Working principles, Typical Air pressure system, Brake system, Typical Pneumatic power system, Components, Landing Gear systems, Classification.	**8 Hours**	**L1,L2**
Module -3 **Engine Systems:** Fuel systems for Piston and jet engines, Components of multi engines. lubricating systems for piston and jet engines - Starting and Ignition systems - Typical examples for piston and jet engines.	**8 Hours**	**L1,L2,L3**
Module -4 **Auxiliary System:** Basic Air cycle systems, Vapour Cycle systems, Evaporative vapour cycle systems, Evaporative air cycle systems, Fire protection systems, Deicing and anti-icing systems.	**8 Hours**	**L1,L2,L3**
Module -5 **Aircraft Instruments:** Flight Instruments and Navigation Instruments, Gyroscope, Accelerometers, Air speed Indicators, TAS, EAS, Mach Meters, Altimeters, Principles and operation, Study of various types of engine instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles.	**8 Hours**	**L1,L2,L3**

Course Outcomes:

After studying this course, students will be able to:

1. Distinguish the conventional and modern control systems.
2. Classify the aircraft systems.
3. Categorize different types of aircraft instruments.

Graduate Attributes:

- Engineering Knowledge.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Ian Moirand Allan Seabridge, ‘Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem Integration’, Wiley India Pvt Ltd, 3rd edition, 2012, ISBN-13: 978-8126535217.
2. Pallet, E.H.J., “Aircraft Instruments and Integrated Systems”, Longman Scientific and Technical, 1996.

Reference Books:

1. Lalit Gupta and OP. Sharma, ‘Aircraft Systems (Fundamentals of Flight Vol. IV)’,

HimalayanBooks;2006.
2. Treager. S, "Gas Turbine Technology", McGraw-Hill, 3rd edition,2013, ISBN-13: 978-1259064876.
3. R.W. Sloley and W.H. Coulthard, 'The aircraft Engineers Handbook, No 4, Instruments', 6th Edition, 2005, ISBN-13: 978-8175980518
4. SR. Majumdar,'Pneumatic Systems', Tata McGraw Hill Publishing Co,1st Edition, 2001, ISBN-13: 978-0074602317.
5. William A Neese, 'Aircraft Hydraulic Systems', Himalayan Books, 2007.

Open Electives

HISTORY OF FLIGHT & TECHNOLOGY FORECAST

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V
Open Elective

Subject Code	**17AE561**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives:
This course will enable students to
1. Study the basic concepts of flying.
2. Understand about the aircraft structures and materials.
3. Acquire the knowledge of aircraft power plants.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction** Early Developments – Ornithopters, Balloon Flight, Sir George Cayley – The true inventor of Airplane, the Interregnum, Otto Lilienthal – The Glider Man, Percy Pilcher – Extending the Glider Tradition.	**8 Hours**	**L1, L2**
Module -2 Wilbur and Orville Wright – Inventors of First Practical Airplane, Aeronautical Triangle – Langley, Wrights and Glenn Curtiss, Problem of Propulsion, Faster and Higher, biplanes and monoplanes, Developments in aerodynamics, materials, structures and propulsion over the years.	**8 Hours**	**L1, L2**
Module-3 **Aircraft Configurations:** Different types of flight vehicles, classifications. Components of an airplane and their functions. Conventional control, Powered control, Basic instruments for flying - Typical systems for control actuation.	**8 Hours**	**L1, L2, L3**

Module -4 **Airplane Structures and Materials:** General types of construction, Monocoque, semi-monocoque and geodesic constructions, Typical wing and fuselage structure. Metallic and non-metallic materials, Use of aluminium alloy, titanium, stainless steel and composite materials. Stresses and strains – Hooke’s law – Stress - strain diagrams - elastic constants.	**8 Hours**	**L1, L2**
Module -5 **Power Plants:** Basic ideas about piston, turboprop and jet engines - Use of propeller and jets for thrust production - Comparative merits, Principles of operation of rocket, types of rockets and typical applications, Exploration into space.	**8 Hours**	**L1, L2**

Course Outcomes:
After studying this course, students will be able to:
1. Identify the aspects of aircrafts.
2. Classify the aircraft materials.
3. Describe the instruments and power plants used in airplanes.

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Anderson, J.D., “Introduction to Flight”, McGraw-Hill, 1995.
2. Stephen. A. Brandt, Introduction to Aeronautics: A design perspective, 2nd Edition, AIAA Education Series, 2004..

Reference Books:
1. Kermode, A.C., “Mechanics of Flight”, Himalayan Book, 1997
2. Kermode, A.C., “Flight without Formula”, Pearson, 2009.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

Elements of Aeronautics

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Open Elective

Subject Code	**17AE562**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objectives: This course will enable students to

4. To know the history and basic principle of aviation
5. To understand the foundation of flight, aircraft structures, material aircraft propulsion
6. To develop an understanding stability of an aircraft along with its different systems.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction to Aircrafts** History of aviation; Atmosphere and its properties; Classification of aircrafts; Basic components of an aircraft; structural members; aircraft axis system; aircraft motions; control surfaces and high lift devices; classification of aircraft; conventional design configurations; principle of operation of each major part; Helicopters, their parts and functions. **Aircraft Structures and Materials:** Introduction; general types of construction; monocoque, semi-monocoque and geodesic structures; typical wing and fuselage structure; metallic and non-metallic materials for aircraft application.	**08 Hours**	**L1, L2**
Module -2 **Basic principles of flight** – significance of speed of sound; airspeed and groundspeed; standard atmosphere; Bernoulli's theorem and its application for generation of lift and measurement of airspeed; forces over wing section, aerofoil nomenclature, pressure distribution over a wing section. Lift and drag components – generation of lift and drag; lift curve, drag curve, types of drag, factors affecting lift and drag; centre of pressure and its significance; aerodynamic centre, aspect ratio, Mach number and supersonic flight effects; simple problems on lift and drag.	**08 Hours**	**L1, L2**
Module -3 **Aircraft Propulsion:** Aircraft power plants, classification based on power plant and location and principle of operation. Turboprop, turbojet and turbofan engines; ramjets and scramjets; performance characteristics. Aircraft power plants – basic principles of piston, turboprop and jet engines; Brayton cycle and its application to gas turbine engines; use of propellers and jets for production of thrust; comparative merits and limitations of different types of propulsion engines; principle of thrust augmentation.	**08 Hours**	**L1, L2, L3**

Module -4 **Aircraft Stability:** Forces on an aircraft in flight; static and dynamic stability; longitudinal, lateral and roll stability; necessary conditions for longitudinal stability; basics of aircraft control systems. Effect of flaps and stats on lift, control tabs, stalling, gliding, landing, turning, aircraft manoeuvres; stalling, gliding, turning. Simple problems on these. Performance of aircraft – power curves, maximum and minimum speeds for horizontal flight at a given altitude; effect of changes in engine power and altitude on performance; correct and incorrect angles of bank; aerobatics, inverted manoeuvre, manoeuvrability. Simple problems.	**08 Hours**	**L1, L2**
Module -5 **Aircraft Systems:** Mechanical systems and their components; hydraulic and pneumatic systems; oxygen System; environmental Control System; fuel system. Electrical systems, flight deck and cockpit systems; navigation system, communication system. **Aircraft systems (Mechanical)** – hydraulic and pneumatic systems and their applications; environment control system; fuel system, oxygen system. **Aircraft systems (Electrical)** – flight control system, cockpit instrumentation and displays; communication systems; navigation systems; power generation systems – engine driven alternators, auxiliary power Module, ram air turbine; power conversion, distribution and management.	**08 Hours**	**L1, L2**

Course outcomes:

After studying this course, students will be able to:

4. Appreciate and apply the basic principle of aviation
5. Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft propulsion and aircraft materials during the development of an aircraft
6. Comprehend the complexities involved during development of flight vehicles.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

5. John D. Anderson, "*Introduction to Flight*", McGraw-Hill Education, 2011. ISBN 9780071086059.
6. Lalit Gupta and O P Sharma, "*Fundamentals of Flight Vol-I to Vol-IV*", Himalayan Books, 2006, ISBN: 706.

Reference Books:

3. A.C. Kermode, "Flight without formulae", Pearson Education India, 1989. ISBN: 9788131713891.
4. Nelson R.C., "Flight stability and automatic control", McGraw-Hill International Editions, 1998. ISBN 9780071158381.
7. Ian Moir, Allan Seabridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 2011. ISBN 978111965006.
8. Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 8th Ed., 2011; ISBN: 1118174208, 9781118174203.

AIRCRAFT TRANSPORTATION SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V

Open Elective

Subject Code	**17AE563**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Understand the air transport systems.
2. Acquire the knowledge of aircraft characteristics, airlines and airport.
3. Understand the navigation and environmental systems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module –I: Air Transport Systems –Introduction Environment, transport and mobility. Systematic description and current challenges. Development of aircraft design driver-speed and range. Development of Airport, Airlines, ICAO, Regulatory Frame work and Market Aspects.	**10 Hours**	**L1, L2**
Module –II: Aircraft Characteristics and Manufacturers Classification of flight vehicles, cabin design, basics of flight physics- structures, mass and balance. Flight performance and mission. Aircraft manufacturers, development process, production process, supply chain.	**08 Hours**	**L1, L2**

Module –III: Airlines, Airport and Infrastructure Airline types, Network management. Flight strategy and aircraft selection, flight operations, MRO. Role of Airport, Regulatory Issues, Airport operation and services. Airport planning - infrastructure.	**8Hours**	**L1, L2, L3**
Module –IV: Air Navigation System & Environmental Systems Principle of operation- Role of Air Navigation services. Air space structures, Airspace and Airport capacity, Aircraft separation. Flight guidance system. Communication system. Integrated air traffic management and working system. Environmental aspects-emission, noise, and sound.	**8 Hours**	**L1, L2, L3**
Module –V: Managerial Aspects of Airlines Airline passenger marketing, forecasting methods, pricing and demand. Air cargo-market for air freight. Principles of airline scheduling. Fleet planning.	**6 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Explain the air transport systems.
2. Describe the aircraft characteristics, airlines and airport operation.
3. Apply the Air Navigation System & Environmental Systems.

Graduate Attributes:

- Engineering Knowledge.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Dieter Shmitt, and Valker Gollnick, Air Transport System, Springer, 2016.

2. Jhon G Wensveen, Air Transportation-A Management Prospective, Ashgate Publishing Ltd, 2011.

Reference Books:

1. Mike Hirst, The Air Transportation System, Woodhead Publishing Ltd, England, 2008.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

BASICS OF ROCKETS & MISSILES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – V
Open Elective

Subject Code	**17AE564**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives:
This course will enable students to

1. Understand the types of space launch vehicles and missiles.
2. Study the solid and liquid rocket motors.
3. Acquire the knowledge on launch vehicle dynamics, attitude control, rocket testing and materials.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities and differences. Some famous space launch vehicles and strategic missiles.	**8 Hours**	**L1, L2**
Module -2 **Solid Propellant Rocket Motor Systems:** Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function, requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II) the Arienne SRB **Liquid Propellant Rocket Motor Systems:** Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration and optimisation – safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.	**8 Hours**	**L1, L2**
Module -3 **Aerodynamics of Rockets and Missiles:** Classification of missiles. Airframe components of rockets and missiles, Forces acting on a missile while passing through atmosphere, method of describing aerodynamic	**8 Hours**	**L1, L2, L3**

forces and moments, lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion, re-entry body design considerations.		
Module -4 **Launch Vehicle Dynamics:** Tsiolskovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories, types. Examples, the Mu 3-S-II, Ariane, Pegasus launchers. Reusable launch vehicles, future launchers, launch assist technologies. **Attitude Control of Rockets and Missiles:** Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.	**8 Hours**	**L1, L2**
Module -5 **Rocket Testing:** Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Description of a typical space launch vehicle launch procedure. **Materials:** Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels.	**8 Hours**	**L1, L2**

Course Outcomes:

After studying this course, students will be able to:

1. Identify the types of space launch vehicles and missiles.
2. Distinguish the solid and liquid propellant motors.
3. Classify different types of materials used for rockets and missies.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. George P Sutton and Oscar Biblarz, 'Rocket Propulsion Element', John Wiley and Sons Inc,7th edition, 2010, ISBN-13: 978-8126525775.
2. Jack N Neilson, 'Missile Aerodynamics', AIAA,1st edition, 1988, ISBN-13: 978-0962062902.

Reference Books:

1. SS. Chin, 'Missile Configuration Design', McGraw Hill, 1961.
2. Cornelisse, J.W, Schoyer H.F.R. and Wakker, K.F., Rocket Propulsion and Space-Flight Dynamics, Pitman, 1979,ISBN-13: 978-0273011415
3. Turner, M.J.L., Rocket and Spacecraft propulsion, Springer,3rd edition, 2010, ISBN-13: 978-3642088698.
4. Ball, K.J., Osborne, G.F., Space Vehicle Dynamics, Oxford University Press, 1967,ISBN-13:978-0198561071
5. Parker, E.R., Materials for Missiles and Spacecraft, McGraw Hill, 1982.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

AERODYNAMICS LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	**17AEL57**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course Objectives: This course will enable students to

1. Be acquainted with basic principles of aerodynamics using wind tunnel.
2. Acquire the knowledge on flow visualization techniques.
3. Understand the procedures used for calculating the lift and drag.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
1. Calibration of a subsonic wind tunnel: test section static pressure and total head distributions.	**L1, L2, L3, L4**
2. Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds.	**L1, L2, L3, L4**
3. Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds	**L1, L2, L3, L4**
4. Smoke flow visualization studies on a two dimensional multi element airfoil with flaps and slats at different angles of incidence at low speeds	**L1, L2, L3, L4**
5. Tuft flow visualization on a wing model at different angles of incidence at low speeds: identify zones of attached and separated flows.	**L1, L2, L3, L4, L5**
6. Surface pressure distributions on a two-dimensional smooth circular cylinder at low speeds and calculation of pressure drag.	**L1, L2, L3, L4**
7. Surface pressure distributions on a two-dimensional rough circular cylinder at low speeds and calculation of pressure drag.	**L1, L2, L3, L4**
8. Surface pressure distributions on a two-dimensional symmetric airfoil	**L1, L2, L3**
9. Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag.	**L1, L2, L3**
10. Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey.	**L1, L2, L3**
11. Calculation of total drag of a two-dimensional cambered airfoil at low speeds at incidence using pitot-static probe wake survey.	**L1, L2, L3**
12. Measurement of a typical boundary layer velocity profile on the tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness.	**L1, L2, L3**
13. Calculation of aerodynamic coefficients forces acting on a model aircraft	**L1, L2, L3**

using force balance at various angles of incidence, speed.	
14. Measurement of a typical boundary layer velocity profile on the airfoil at various angles of incidence from leading edge to trailing edge.	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Apply the flow visualization techniques.
2. Estimate the pressure distribution over the bodies.
3. Calculate the lift and drag.

Conduct of Practical Examination:

5. All laboratory experiments are to be included for practical examination.
6. Students are allowed to pick one experiment from the lot.
7. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
8. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

ENERGY CONVERSION AND FLUID MECHANICS LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – V

Subject Code	**17AEL58**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course Objectives: This course will enable students to

1. Familiarize with the flash point, fire point and viscosity of lubricating oils.
2. Study IC engine parts, opening and closing of valves to draw the valve-timing diagram.
3. Gain the knowledge of various flow meters and the concept of fluid mechanics.
4. Understand the Bernoulli's Theorem.

Modules	Revised Bloom's Taxonomy (RBT) Level
1. Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Pensky Martins Apparatus.	**L1, L2, L3, L4**
2. Determination of Calorific value of solid, liquid and gaseous fuels	**L1, L2, L3, L4**
3. Determination of Viscosity of lubricating oil using Torsion viscometers	**L1, L2, L3, L4**
4. Valve Timing diagram of 4-stroke IC Engine	**L1, L2, L3, L4**
5. Calculation of work done and heat transfer from PV and TS diagram using Planimeter	**L1, L2, L3, L4, L5**
6. Performance Test on **Four stroke Petrol Engine** and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet.	**L1, L2, L3, L4**
7. Performance Test on Four stroke Multi-cylinder Engine and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet.	**L1, L2, L3, L4**
8. Calibration of Venturimeter	**L1, L2, L3**
9. Determination of Coefficient of discharge for a small orifice by a constant head method.	**L1, L2, L3**
10. Determination of Viscosity of a Fluid	**L1, L2, L3**
11. Calibration of contracted Rectangular Notch	**L1, L2, L3**

12. Verification of Bernoulli's equation.	**L1, L2, L3**
13. Pipe friction apparatus with loss of head on pipe fittings	**L1, L2, L3**
14. Determination of Coefficient of loss of head in a sudden contraction and friction factor.	

Course Outcomes:

After studying this course, students will be able to:

1. Operate the instrument and measure the BP, FP, IP and AF ratio.
2. Find the efficiency of the engine and Estimate the calorific value of the given fuel.
3. Verify the Bernoulli's equation.
4. Evaluate the viscosity of fluid.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

B.E. AERONAUTICAL ENGINEERING

VI SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/Drawing	Duration	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	17AE61	AERODYNAMICS-II	04		03	60	40	100	4
2	17AE62	GAS TURBINE TECHNOLOGY	04		03	60	40	100	4
3	17AE63	AIRCRAFT PERFORMANCE	04		03	60	40	100	4
4	17AE64	AIRCRAFT STRUCTURES-II	04		03	60	40	100	4
5	17AE65X	PROFESSIONAL ELECTIVE	03		03	60	40	100	3
6	17AE66X	OPEN ELECTIVE	03		03	60	40	100	3
7	17AEL67	AIRCRAFT PROPULSION LAB		1I+2P	03	60	40	100	2
8	17AEL68	AIRCRAFT STRUCTURES LAB		1I+2P	03	60	40	100	2
TOTAL			**22**	**06**	**24**	**480**	**320**	**800**	**26**

PROFESSIONAL ELECTIVE		OPEN ELECTIVE	
17AE651	FINITE ELEMENT METHOD	17AE661	UNMANNED AERIAL VEHICLES BASICS & APPLICATIONS
17AE652	EXPERIMENTAL AERODYNAMICS	17AE662	FUNDAMENTALS OF AERODYNAMIC THEORY
17AE653	SPACE MECHANICS	17AE663	ELEMENTS OF JET PROPULSION SYSTEMS
17AE654	EXPERIMENTAL STRESS ANALYSIS	17AE664	MAINTENANCE, OVERHAUL & REPAIR OF AIRCRAFT SYSTEMS

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
2. **Professional Elective:** Elective relevant to chosen specialization/ branch
3. **Open Elective**: Electives from other technical and/or emerging subject areas.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

AERODYNAMICS - II

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VI

Subject Code	**17AE61**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the concepts of compressible flow and shock phenomenon
2. Acquire the knowledge of oblique shock and expansion wave formation.
3. Appreciate the measurement in high speed flow.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **One Dimensional Compressible Flow:** Energy, Momentum, continuity and state equations, velocity of sound, Adiabatic steady state flow equations, Flow through converging, diverging passages, Performance under various back pressures. Numericals.	**10 Hours**	**L1, L2**
Module -2 **Normal Shock:** Prandtl Meyer equation and Rankine – Hugonoit relation, Normal shock equations: Property ratios in terms of upstream Mach number, Numericals, Moving Normal Shock wave.	**10 Hours**	**L1, L2**
Module -3 **Oblique shocks and Expansion waves:** Prandtl equation and Rankine – Hugonoit relation, Normal shock equations, Pitot static tube, corrections for subsonic and supersonic flows, Oblique shocks and corresponding equations, Hodograph and pressure turning angle, shock polars, flow past wedges and concave corners, strong, weak and detached shocks, Flow past convex corners, Prandtl –Meyer expansion function, Reflection and interaction of shocks and expansion, waves, Families of shocks. Flow with Friction and Heat transfer.	**10 Hours**	**L1, L2, L3**
Module -4 **Differential Equations of Motion for Steady Compressible Flows:** Basic potential equations for compressible flow. Linearisation of potential equation-small perturbation theory. Methods for solution of nonlinear potential equation –Introduction, Method of characteristics, Boundary conditions, Pressure coefficient expression, small perturbation equation for compressible flow - Prandtl, Glauret and Geothert's rules - Ackert's supersonic airfoil theory, Von-Karman rule for transonic flow, Lift, drag pitching moment and center of pressure of	**10 Hours**	**L1, L2,L3**

supersonic profiles.		
Module -5 **Measurements in High speed Flow:** Types of subsonic wind tunnels - Balances and measurements - Interference effects- transonic, Supersonic and hypersonic wind tunnels and characteristic features, their operation and performance - Shock tubes and shock tunnels - Free flight testing - Measurements of pressure, velocity and Mach number -Flow visualization methods of subsonic and supersonic flows.	**10 Hours**	**L1, L2,L3**

Course Outcomes: After studying this course, students will be able to:

1. Utilize the concepts of compressible flow and shock phenomenon
2. Apply knowledge of oblique shock and expansion wave formation.
3. Measure the parameters high speed flow.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. John D Anderson, “Modern Compressible Flow”, Mc Graw Hill,3rd edition, 2012, ISBN-13: 978-1259027420.
2. Radhakrishnan, E., “Gas Dynamics”, Prentice Hall of India,5th edition,2014,ISBN-13: 978-8120348394

Reference Books:

1. Ascher. H. Saphiro, “Dynamics and Thermodynamics of Compressible fluid flow”, John Wiley & Sons,1st edition,1977, ISBN-13: 978-0471066910.
2. Yahya, S.M., “Fundamentals of Compressible flow”, NEW AGE, 2009, ISBN-13: 978-8122426687.
3. H.W. Liepmann and A. Roshko, “Elements of Gas Dynamics”, Dover Publications Inc,2003, ISBN-13: 978-0486419633.
4. Hodge B. K, Koenig K, Compressible Fluid Dynamics with Computer Application, 1st edition, Prentice Hall, New York (1995).
5. Clancy L. J., Aerodynamics, Shroff Publishers, 2006, ISBN-13: 978-8175980570.
6. Zucrow, M.J. and Anderson, J.D., “Elements of gas dynamics”, McGraw - Hill Book Co., New York, 1989.

GAS TURBINE TECHNOLOGY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	**17AE62**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Comprehend the types of engines and its applications.
2. Understand the materials required for engine manufacturing.
3. Acquire the knowledge of engine performance and testing.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Types, Variation & Applications:** Types of engines showing arrangement of parts. Operating parameters. Energy distribution of turbojet, turboprop and turbofan engines. Comparison of thrust and specific fuel consumption. Thrust, pressure and velocity diagrams. **Engine Parts:** Compressor assembly, types of burners: advantages and disadvantages. Influence of design factors on burner performance. Effect of operating variables on burner performance. Performance requirements of combustion chambers. Construction of nozzles. Impulse turbine and reaction turbine. Exhaust system, sound suppression. Thrust reversal: types, design & systems. Methods of thrust augmentation, after burner system.	**10 Hours**	**L1, L2**
Module -2 **Materials and Manufacturing:** Criteria for selection of materials. Heat ranges of metals, high temperature strength. Surface finishing. Powder metallurgy. Use of composites and Ceramics. Super alloys for Turbines. **Systems:** Fuel systems and components. Sensors and Controls. FADEC interface with engine. Typical fuel system. Oil system components. Typical oil system. Starting systems. Typical starting characteristics. Various gas turbine starters.	**10 Hours**	**L1, L2**
Module -3 **Engine Performance:** Design & off - design Performance. Surge margin requirements, surge margin stack up. Transient performance. Qualitative characteristics quantities. Transient working lines. Starting process & Wind milling of Engines. Thrust engine start envelope. Starting torque and speed requirements Calculations for design and off-design performance from given test data– (case study for a single shaft Jet Engine).Engine performance monitoring.	**10 Hours**	**L1, L2, L3**
Module -4 **Compressor:** Compressor MAP. Surge margin, Inlet distortions. Testing and Performance Evaluation. **Combustor:** Combustor MAP, Pressure loss, combustion light up test. Testing and Performance	**10 Hours**	**L1, L2**

Evaluation. **Turbines:** Turbine MAP. Turbine Testing and Performance Evaluation. **Inlet duct & nozzles:** Ram pressure recovery of inlet duct. Propelling nozzles, after burner, maximum mass flow conditions. Testing and Performance Evaluation		
Module -5 **Engine Testing:** Proof of Concepts: Design Evaluation tests. Structural Integrity. Environmental Ingestion Capability. Preliminary Flight Rating Test, Qualification Test, Acceptance Test. Reliability figure of merit. Durability and Life Assessment Tests, Reliability Tests. Engine testing with simulated inlet distortions and, surge test. Estimating engine-operating limits. Methods of displacing equilibrium lines. **Types of engine testing's:** Normally Aspirated Testing, Open Air Test Bed, Ram Air Testing, Altitude Testing, Altitude test facility, Flying Test Bed, Ground Testing of Engine Installed in Aircraft, Flight testing. Jet thrust measurements in flight. Measurements and Instrumentation. Data Acquisition system, Measurement of Shaft speed, Torque, Thrust, Pressure, Temperature, Vibration, Stress, Temperature of turbine blading etc. Engine performance trends: Mass and CUSUM plots. Accuracy and Uncertainty in Measurements. Uncertainty analysis. Performance Reduction Methodology.	**10 Hours**	**L1, L2**

Course Outcomes:
After studying this course, students will be able to:
1. Select the suitable materials for engine manufacturing.
2. Evaluate the performance of the engine.
3. Test the engine using several types of engine testing methods.

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Irwin E. Treager, **'**Gas Turbine Engine Technology ', Mc Graw Hill Education,3rd edition, 2013, ISBN-13: 978-1259064876
2. P.P Walsh and P. Peletcher, 'Gas Turbine Performance' Blackwell Science, 1998, ISBN0632047843.

Reference Books:
1. Advanced Aero-Engine Testing, AGARD-59, Publication.
2.MIL–5007E, 'Military Specifications: Engine, Aircraft, Turbo Jet & Turbofan; General Specification for Advance Aero Engine testing',1973.
3. J P Holman, 'Experimental methods for Engineers ', Tata Mc Graw Hill,7th edition,2007, ISBN-13: 978-0070647763
4. A S Rangawala, Turbomachinery Dynamics-Design and operations, McGraw–Hill, 2005, ISBN-13: 978-0071453691.
5. Michael J.Kores, and Thomas W.Wild**,**' Aircraft Power Plant', GLENCOE Aviation Technology Series, 7th Edition, Tata Mc Graw Hill Publishing Co.Ltd.2002.

AIRCRAFT PERFORMANCE

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VI

Subject Code	**17AE63**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the aircraft performance in steady unaccelerated and accelerated flight.
2. Understand the airplane performance parameters.
3. Acquire the knowledge on aircraft maneuver performance.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **The Equations of Motion Steady Unaccelerated Flight** Introduction, four forces of flight, General equation of motion, Power available and power required curves. Thrust available and thrust required curves. Conditions for power required and thrust required minimum. Thrust available and maximum velocity, Power available and maximum velocity, Altitude effects on power available and power required; thrust available and thrust required.	**10 Hours**	**L1, L2**
Module -2 **Steady Performance – Level Flight, Climb & Glide** Performance: Equation of motion for Rate of climb- graphical and analytical approach -Absolute ceiling, Service ceiling, Time to climb – graphical and analytical approach, climb performance graph (hodograph diagram); maximum climb angle and rate of climb Gliding flight, Range during glide, minimum rate of sink and shallowest angle of glide.	**10 Hours**	**L1, L2**
Module -3 **Fundamental Airplane Performance Parameters** The fundamental Parameters: Thrust – to – weight ratio, Wing loading, Drag polar, and lift-to – drag ratio. Minimum velocity. Aerodynamic relations associated with lift-to-drag ratio. **Range and Endurance:** Propeller driven Airplane: Physical consideration, Quantitative formulation, Breguet equation for Range and Endurance, Conditions for maximum range and endurance. Jet Airplane: Physical consideration, Quantitative formulation, Equation for Range and Endurance, Conditions for maximum range and endurance, Effect	**10 Hours**	**L1, L2, L3**

of head wind tail wind.		
Module -4 **Aircraft Performance in Accelerated Flight** **Take-off Performance**: Calculation of Ground roll, Calculation of distance while airborne to clear obstacle, Balanced field length **Landing Performance and Accelerated Climb:** Calculation of approach distance, Calculation of flare distance, Calculation of ground roll, ground effects. Acceleration in climb.	**10 Hours**	**L1, L2, L3**
Module -5 **Maneuver Performance** Turning performance: Level turn, load factor, Constraints on load factor, Minimum turn radius, Maximum turn rate. Pull-up and Pull-down maneuvers: (Turning rate, turn radius). Limiting case for large load factor. The V-n diagram. Limitations of pull up and push over.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Apply the basic airplane performance parameters.
2. Differentiate the aircraft performance in steady unaccelerated and accelerated flight.
3. Explain the aircraft maneuver performance.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. **John D. Anderson, Jr.** “Aircraft Performance and Design”, McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 1999.
2. **John D. Anderson, Jr.**, “Introduction to flight” McGraw-Hill International Editions, Aerospace Science/ Technology Editions, 2000.

Reference Books:

1. **Perkins, C.D., and Hage, R.E.**, “Airplane Performance stability and Control”, John Wiley Son Inc, New York, 1988.

2. **Barnes W. McCormick,** ` Aerodynamics, Aeronautics, and Flight Mechanics`, John Wiley& Sons, Inc. 1995.

AIRCRAFT STRUCTURES - II

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VI

Subject Code	**17AE64**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course objective: This course will enable students to

1. Understand the concepts of open and closed thin walled beams.
2. Acquire the knowledge of buckling of plates, joints and fittings.
3. Comprehend the stress analysis on wings and fuselage.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Bending and shear- Open and Closed Thin Walled Beams** Symmetrical bending, unsymmetrical bending, direct stress distribution due to bending, position of the neutral axis, load intensity, shear force, and bending moment relationships, deflection due to bending, calculation of section properties, approximation for thin-walled sections. **Shear of beams-** General stress, strain, and displacement relationship for open and single-cell closed section thin-walled beams, shear of open section beams, shear centre, shear of closed section beams. Torsion of close section beam, and displacement associated with the Bredt-Batho shear flow. Torsion of open section beam.	**10 Hours**	**L1, L2**
Module -2 **Combined Open and Closed Section Beams, and Structural Idealisation** Bending, shear, torsion. Structural idealisation-Principle, Idealisation of a panel, effect of idealisation on the analysis of open and closed section beams. Bending of open and closed section idealised beams, shear of open section and closed section idealised beams. Deflection of open and closed section idealised beams.	**10 Hours**	**L1, L2**
Module -3 **Buckling of Plates, Joints and Fittings** Buckling of Isotropic flat plates in compression, ultimate compressive strength of Isotropic flat sheet, plastic buckling of flat sheet, columns subjected to local crippling failure, Needham & Gerard method for determining crippling stress, curved sheets in compression, elastic buckling of curved rectangular plates. Pure tension field beams, angle of	**10 Hours**	**L1, L2, L3**

diagonal tension in web. **Joints and Fittings**- bolted or riveted joints, accuracy of fitting analysis, eccentrically loaded connections, welded joints, and concept of effective width.		
Module -4 **Stress Analysis in Wing Spars and Box beams** Tapered wing spar, open and closed section beams, beams having variable stringer areas, three- boom shell, torsion and shear, tapered wings, cut-outs in wings.	**10 Hours**	**L1, L2,L3**
Module -5 **Stress Analysis in Fuselage Frames** Bending, shear, torsion, cut-outs in fuselages, principles of stiffeners construction, fuselage frames, shear flow distribution.	**10 Hours**	**L1, L2,L3**

Course Outcomes: After studying this course, students will be able to:

1. Utilize the concepts of thin walled beams.
2. Calculate the buckling of plates.
3. Analysis the stress in wings and fuselage frames.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Megson, T. H. G., Aircraft Structures for Engineering Students, Edward Arnold,1995.
2. Peery D J & Azar J J, Aircraft Structures, 2nd edition, McGraw Hill N.Y.,1993

Reference Books:

1. Bruhn E. F., Analysis & Design of Flight Vehicles Structures, Tri-State offset Co, USA,1985.
2. Megson, T. H. G., Introduction to Aircraft Structural Analysis, Elsevier, 2nd Edition, 2014.
3. Bruce K Donaldson, Analysis of Aircraft Structures, Cambridge Aerospace Series, 1992.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

FINITE ELEMENT METHOD

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Professional Elective

Subject Code	**17AE651**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Understand the importance of discretisation of domain using different finite elements
2. Acquire the knowledge of different loading and boundary conditions
3. Understand the governing methods of finite element analysis

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction: Basic Concepts, Background Review:** Stresses and Equilibrium, Plane stress, Plane strain, Potential energy and Equilibrium. Rayleigh - Ritz Method, Galerkin's Method, Simple applications in structural Analysis. Construction or discrete models - sub domains and nodes - simple elements for the FEM - Simplex, complex and multiples elements Polynomial selection -illustrative examples Elements and shape functions and natural coordinates, Use of local and natural coordinates, compatibility and convergence requirements of shape functions.	**10 Hours**	**L1,L2**
Module -2 **Fundamentals of Finite Element Method:** Construction of shape functions for bar element and beam element, Bar elements, uniform bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis, Frame element, Beam element, problems for various loadings and boundary conditions.	**06 Hours**	**L1,L2**
Module -3 **Analysis of Two and Three dimensional Elements:** Shape functions of Triangular, Rectangular and Quadrilateral elements, different types of higher order elements, constant and linear strain triangular elements, stiffness matrix Four-Noded Tetrahedral Element (TET 4), Eight-Noded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family.	**08 Hours**	**L1, L2,L3**
Module -4 **Theory of Isoparametric Elements and Axisymmetric:** Isoparametric, sub parametric and super-parametric elements, characteristics of Isoparametric quadrilateral elements, structure of computer program for FEM analysis, description of different modules, pre and post processing, Axisymmetric formulation finite element modeling of triangular and quadrilateral element.	**08 Hours**	**L1, L2,L3**

Module -5	**08 Hours**	**L1,L2,L3**
Field Problems: Heat transfer problems, Steady state fin problems, 1D heat conduction governing equation, Derivation of element matrices for two dimensional problems, Dynamic consideration- Formulation- Hamilton's principle, Element mass matrices.		

Course Outcomes:
After studying this course, students will be able to:
1. Apply discretisation technique for domain decomposition.
2. Evaluate the effects of different loading and boundary conditions
3. Analyze the governing equations of finite element analysis

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Chandrupatla T. R., "Finite Elements in engineering", PHI, 3rd edition, 2002, ISBN-13: 978-8120321069.
2. Bhavikatti, Finite element Analysis, New Age International,3rd edition,2015, ISBN-13: 978-8122436716

Reference Books:

1. Rajasekharan. S - "Finite element analysis in engineering design", Wheeler Publishers
2. Bathe. KJ, "Finite Element Procedures", PHI Pvt. Ltd., New Delhi,1996, ISBN-13: 978-8126529988
3. Zienkiewicz. O.C. - "The Finite Element Method", Elsevier,7th edition,2013, ISBN-13: 978-9351071587
4. Rao S. S., "Finite Elements Method in Engineering", Elsevier,5th edition, 2008, ISBN-13: 978-9380931555
5. C.S. Krishnamurthy - "Finite Element analysis - Theory and Programming", Tata McGraw Hill Co. Ltd, New Delhi,2nd edition,2011,ISBN-13: 978-0074622100.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2017-2018

EXPERIMENTAL AERODYNAMICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Professional Elective

Subject Code	**17AE652**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives:

This course will enable students to

1. Understand the basics of experimental aerodynamics.
2. Understand the procedures for model measurements.
3. Acquire the knowledge of wind tunnel testing.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Wind Energy Collectors:** Horizontal axis and vertical axis machines. Power coefficient. Betz coefficient by momentum theory. **Vehicle Aerodynamics:** Power requirements and drag coefficients of automobiles. Effects of cut back angle. Aerodynamics of Trains and Hovercraft.	**8 Hours**	**L1, L2**
Module -2 **Building Aerodynamics:** Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city blocks, Special problems of tall buildings, building codes, building ventilation and architectural aerodynamics. **Flow Induced Vibrations:** Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping and stall flutter.	**8 Hours**	**L1, L2**
Module -3 **Model Measurements:** Balances: design, installation and, calibration. Internal balances. Mounting of models, rigidity. Measurement of interference. Lift and drag measurements through various techniques. Testing procedures. Testing: - 3-D wings, controls, complete model, power effects, aero elasticity, dynamic stability. Testing with ground plane, testing wind mill generator. Testing for local loads. Testing of rotor. Testing engines, Jettison tests. Data reduction. Data correction.	**8 Hours**	**L1, L2, L3**
Module -4 **Wind Tunnel Boundary Corrections and Scale Effects:** Effects of lateral boundaries. Method of images. Wall corrections. Effects of Buoyancy, Solid Blocking, Wake Blocking. General downwash correction. Lift interference correction. Corrections for reflection plane models. Scale effects on aerodynamic characteristics and stability derivatives	**8 Hours**	**L1, L2**

Module -5	8 Hours	L1, L2
Near sonic and Transonic Testing: Near sonic tunnel design. Calibration of test section. Model support system. Tare and interference evaluation. Near transonic testing. **Supersonic Wind Tunnel Testing:** Types of supersonic tunnels: - continuous, intermittent (indraft and blowdown). Pressure-vacuum tunnels. Supersonic tunnel design features. Calibration of test section. Optical systems- Schlieren set-up. Starting loads. Hypersonic wind tunnels - General introduction		

Course Outcomes:

After studying this course, students will be able to:

1. Distinguish the building and vehicle aerodynamics.
2. Evaluate the boundary corrections and scale effects.
3. Classify the wind tunnel testing.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Jewel B. Barlow, William H RAE, Jr. and Alan Pope, 'Low speed Wind Tunnel Testing', John Wiley & Sons,3rd edition,2010,ISBN-13: 978-8126525683
2. M. Sovran (Ed), "Aerodynamics and drag mechanisms of bluff bodies and road Vehicles", Plenum press, New York, 1978.

Reference Books:

1. P. Sachs, "Winds forces in engineering", Pergamon Press, 2nd edition,2013.
2. R.D. Blevins, "Flow induced vibrations", Van Nostrand,1990.
3. N.G. Calvent, "Wind Power Principles", Calvert Technical Press ,2nd edition,2004.
4. E. Rathakrishnan, Instrumentation, Measurements and Experiments in Fluids, CRC Press, 2007.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2017-2018

SPACE MECHANICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Professional Elective

Subject Code	**17AE653**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Understand the basic concepts of space mechanics and the general N-body.
2. Study satellite injection and satellite orbit perturbations.
3. Acquire the knowledge of interplanetary and ballistic missile trajectories.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Space Environment:** Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite life time.	**08 Hours**	**L1, L2**
Module -2 **Basic Concepts and the General N-Body:** The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts, Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, the many body problem, Lagrange-Jacobi identity, the circular restricted three body problem, libration points, the general N-body problem, two body problem, relations between position and time.	**08 Hours**	**L1, L2**
Module -3 **Satellite Injection and Satellite Perturbations**: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.	**08 Hours**	**L1, L2, L3**
Module -4 **Interplanetary Trajectories**: Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem.	**08 Hours**	**L1, L2**

Module -5 **Ballistic Missile Trajectories:** Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights , time of flight, re-entry phase, the position of impact point, influence coefficients.	**08 Hours**	**L1, L2**

Course Outcomes:

At the end of this course the student will be able to:

1. Apply the basic concepts of space mechanics and the general N-body.
2. Explain satellite injection and satellite orbit perturbations.
3. Distinguish between interplanetary and ballistic missile trajectories.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Cornelisse, J.W., Rocket Propulsion and Space Dynamics, W.H. Freeman&co,1984.
2. Thomson, Introduction to Space Dynamics, Dover Publications, Revised edition,2012.

Reference Books:

1. Vande Kamp, P., "Elements of Astromechanics", Pitman,1979
2. Willian E. Wiesel, Space Flight Dynamics, Create Space Independent Publishing Platform, 3rd Edition , 2010, ISBN-13: 978-1452879598
3. George P. Sutton and Oscar Biblarz, Rocket Propulsion Elements, Wiley India Pvt Ltd,7th edition, 2010, ISBN-13: 978-8126525775.

EXPERIMENTAL STRESS ANALYSIS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Professional Elective

Subject Code	**17AE654**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Understand the basics of measurements.
2. Study about the electrical resistance strain gauges.
3. Acquire the knowledge of NDT.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Measurements:** Principles of measurements, Accuracy, Sensitivity and range of measurements.	**8 Hours**	**L1, L2**
Module -2 **Extensometers:** Mechanical, Optical, Acoustical and Electrical extensometers and their uses. Advantages and disadvantages.	**8 Hours**	**L1, L2**
Module -3 **Electrical Resistance Strain Gauges:** Principle of operation and requirements of electrical strain gauges. Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross sensitivity, Rosette analysis. Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators.	**8 Hours**	**L1, L2, L3**
Module -4 **Photo Elasticity:** Two dimensional photo elasticity, Concept of light, photo elastic effects, stress optic law, Interpretation of fringe pattern, Compensation and separation techniques, Photoelastic, materials. Introduction to three dimensional photo elasticity.	**8 Hours**	**L1, L2**
Module -5 **Nondestructive Testing:** Fundamentals of NDT. Radiography, ultrasonic, magnetic particle inspection, Fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique, Fundamentals of brittle coating methods, Introduction to Moire techniques, Holography, ultrasonic C- Scan, Thermograph, Fiber-optic Sensors.	**8 Hours**	**L1, L2**

Course Outcomes:

After studying this course, students will be able to:

1. Classify the types of extensometers.
2. Use the electrical resistance strain gauges.
3. Identify the different methods of NDT.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1.Srinath,L.S., Raghava, M.R., Lingaiah, K., Garagesha, G., Pant B., and Ramachandra, K., "Experimental Stress Analysis", Tata Mc Graw-Hill,NewDelhi,1914.

2. Dally J.W., and Riley,W.F.,"Experimental Stress Analysis", Mc Graw-Hill Inc., New York, 3rd Edition, 1991,ISBN-13: 978-0071008259.

Reference Books:

1. Hetyenyi, M.," Handbook of Experimental Stress Analysis", John Wiley, NewYork,1972.
2. Pollock A.A.,"Acoustic Emission in Acoustics and Vibration Progress", Ed. Stephens R.W.B., Chapman and Hall,1993.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2017-2018

UNMANNED AERIAL VEHICLES BASICS & APPLICATIONS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Open Elective

Subject Code	**17AE661**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the basic aviation history and UAV systems.
2. Acquire the knowledge of basic aerodynamics, performance, stability and control.
3. Understand the propulsion, loads and structures.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction** Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals, Examples of UAV systems-very small, small, Medium and Large UAV	**6 Hours**	**L1, L2**
Module -2 **The Air Vehicle** **Basic Aerodynamics:** Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag **Performance:** Overview, climbing flight, Range and Endurance – for propeller-driven aircraft, range- a jet-driven aircraft, Guiding Flight	**6 Hours**	**L1, L2**
Module -3 **Stability and Control** Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.	**8 Hours**	**L1, L2, L3**

Module -4 **Propulsion** Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, Sources of Electrical Power **Loads and Structures** Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques	**10 Hours**	**L1, L2, L3**
Module -5 **Mission Planning and Control:** Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Tradeoffs	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts of UAV systems.
2. Explain the basic aerodynamics, performance, stability and control required for UAV.
3. Select the propulsion system and materials for structures.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Paul Gerin Fahlstrom, Thomas James Gleason, Introduction to UAV Systems, 4th Edition, Wiley Publication, 2012 John Wiley & Sons, Ltd
2. Landen Rosen, Unmanned Aerial Vehicle, Publisher: Alpha Editions, ISBN13: 9789385505034.

Reference Books:

1. Unmanned Aerial Vehicles: DOD's Acquisition Efforts, Publisher: Alpha Editions, ISBN13: 9781297017544.
2. Valavanis, Kimon P., Unmanned Aerial Vehicles, Springer, 2011.
3. Valavanis, K., Vachtsevanos, George J., Handbook of Unmanned Aerial Vehicles, Springer, 2015.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2017-2018

FUNDAMENTALS OF AERODYNAMIC THEORY

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Open Elective

Subject Code	**17AE662**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objectives: This course will enable students to

4. Understand the basics of fluid mechanics as a prerequisite to Aerodynamics
5. Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and study the incompressible over finite wings
6. Assimilate the understanding of application of finite wing theory and high lift systems

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Review of Basic Fluid Mechanics** Continuity, momentum and energy equation, Control volume approach to Continuity, momentum and energy equation, Types of flow, pathlines, streamlines, and streaklines, units and dimensions, inviscid and viscous flows, compressibility, Mach number regimes. Vorticity, Angular velocity, Stream function, velocity potential function, Circulation, Numericals, Mach cone and Mach angle, Speed of sound.	**08 Hours**	**L1, L2**
Module -2 **Airfoil Characteristics** Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, centre of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. Types of drag-Definitions.	**08 Hours**	**L1, L2**
Module -3 **Two Dimensional Flows & Incompressible Flow Over Airfoil** Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink. Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow. Lifting flow over a circular cylinder. Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, Numericals, **Incompressible flow over airfoils:** Kelvin's circulation theorem and the starting vortex, vortex sheet, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils. Kutta-Joukowski theorem and generation of Lift, Numericals.	**08 Hours**	**L1, L2, L3, L4, L5**

Module -4 **Incompressible Flow Over Finite Wings** Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortex filament, Induced velocity. Prandtl's classical lifting line theory: Downwash and induced drag. Elliptical and modified elliptical lift distribution. Lift distribution on wings. Limitations of Prandtl's lifting line theory. Extended lifting line theory- lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane.	**08 Hours**	**L1, L2**
Module -5 **Applications of Finite Wing Theory & High Lift Systems** Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, typical aerodynamic characteristics, Subsonic and Supersonic leading edges. Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. critical Mach numbers, Lift and drag divergence, shock induced separation, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects. Introduction to Source panel & vortex lattice method.	**08 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

4. Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
5. Compute and analyse the incompressible flow over finite wings
6. Apply finite wing theory and design high lift systems from the aerodynamics view point

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

3. Anderson J.D, "Fundamental of Aerodynamics", 5th edition, McGraw-Hill International Edition, New York (2011), ISBN-13: 978-0073398105.
4. E. L. Houghton, P.W. Carpenter, "Aerodynamics for Engineering Students", 5th edition, Elsevier, New York. (2010), ISBN-13: 978-0080966328

Reference Books:

3. Clancy L. J. "Aerodynamics", Sterling book house, New Delhi. (2006), ISBN 13: 9780582988804
4. Louis M. Milne-Thomson, "Theoretical Aerodynamics", Imported Edition, Dover Publications, USA (2011), ISBN 9780486619804.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

ELEMENTS OF JET PROPULSION SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Open Elective

Subject Code	**17AE663**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objectives: This course will enable students to

4. Understand the basic principle and theory of aircraft propulsion.
5. Understand the purpose of a centrifugal, axial compressors, axial and radial turbines
6. Acquire knowledge of importance of nozzles & inlets and combustion chamber

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles of internal combustion engine, Two – stroke and four – stroke piston engines, Gas- turbine engines, Cycle analysis of reciprocating engines and jet engines , advantages and disadvantages.	**08 Hours**	**L1, L2**
Module -2 **Propeller Theories & Jet propulsion** Types of propeller, Propeller thrust: momentum theory, Blade element theories, propeller blade design, propeller selection. **Jet Propulsion:** Illustration of working of gas turbine engine – The thrust equation – Factors affecting thrust – Effect of pressure, velocity and temperature changes of air entering compressor – Methods of thrust augmentation – Characteristics of turboprop, turbofan and turbojet – Performance characteristics.	**08 Hours**	**L1, L2, L3**
Module -3 **Inlets & Nozzles** Internal flow and Stall in Subsonic inlets, Boundary layer separation. Major features of external flow near a subsonic inlet. Relation between minimum area ratio and eternal deceleration ratio. Diffuser performance. **Supersonic inlets:** Supersonic inlets, starting problem in supersonic inlets, Shock swallowing by area variation, External deceleration. Modes of inlet operation.	**08 Hours**	**L1, L2**

Nozzles: Theory of flow in isentropic nozzles, Convergent nozzles and nozzle choking, Nozzle throat conditions. Nozzle efficiency, Losses in nozzles. Over-expanded and under-expanded nozzles, Ejector and variable area nozzles, Thrust reversal.		
Module -4 **Gas Turbine Engine Compressors** **Centrifugal compressors:** Principle of operation of centrifugal compressors. Work done and pressure rise -Velocity diagrams, Diffuser vane design considerations. performance characteristics. Concept of Pre-whirl, Rotating stall. **Axial flow compressors:** Elementary theory of axial flow compressor, Velocity triangles, Degree of reaction, three dimensional flow. Air angle distribution for free vortex and constant reaction designs, Compressor blade design. Axial compressor performance characteristics.	**08 Hours**	**L1, L2, L3**
Module -5 **Combustion chambers and Turbines** Classification of combustion chambers, important factors affecting combustion chamber design, Combustion process, Combustion chamber performance Effect of operating variables on performance – Flame tube cooling – Flame stabilization – Use of flame holders **Axial Flow Turbines:** Introduction, Turbine stage, Multi-staging of turbine, Exit flow conditions, Turbine cooling, Heat transfer in turbine cooling. **Radial turbine**: Introduction, Thermodynamics of radial turbines, Losses and efficiency.	**08 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

4. Apply the basic principle and theory of aircraft propulsion.
5. Explain the functions of centrifugal, axial compressors, axial and radial turbines
6. Analyse the performance of nozzles & inlets and combustion chamber

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly).
- Interpretation of data.

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

3. Bhaskar Roy, "Aircraft propulsion", Elsevier (2011), ISBN-13: 9788131214213
4. V. Ganesan, "Gas Turbines", Tata McGraw-Hill, 2010, New Delhi, India, ISBN: 0070681929, 9780070681927

Reference Books:

5. Hill, P.G. & Peterson, C.R., "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 1999, ISBN-13: 978-0201146592.
6. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H., "Gas Turbine Theory", Longman, 1989, ISBN 13: 9780582236325.
7. Irwin E. Treager, "Gas Turbine Engine Technology" GLENCOE Aviation Technology Series, 7th Edition, Tata McGraw Hill Publishing Co. Ltd, 2003, ISBN-13: 978-0028018287
8. S. M. Yahya, "Fundamentals of Compressible Flow with Aircraft and Rocket propulsion", 4th Edition, New Age International Publications, New Delhi 2014, ISBN 13: 9788122426687.

MAINTENANCE, OVERHAUL & REPAIR OF AIRCRAFT SYSTEMS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VI
Open Elective

Subject Code	**17AE664**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objectives: This course will enable students to

1. Comprehend the fundamentals of maintenance and certification.
2. Acquire the knowledge of documentation for maintenance.
3. Understand the Aircraft Maintenance, safety and trouble shooting.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Fundamentals of Maintenance & Certification** Types of maintenance, Redesign, Failure rate pattern, Other	**6 Hours**	**L1, L2**

maintenance considerations. Aviation industry certification requirements, Type certificate (FAA form 8110.9), Airworthiness certificate (FAA form 8100-2), Aviation maintenance certifications, General, Airframe, Power plant, Avionics courses.		
Module -2 **Documentation for Maintenance** Manufacturers documentation, Airplane maintenance manual, Fault insulation manual, Illustrated parts catalogue, structural repair manual, wiring diagram manual, Master minimum equipment, Federal Aviation regulation (FAR), Advisory circulars, Airworthiness direction ATA document standards, Technical policies and procedure manuals (TPPM)	**6 Hours**	**L1, L2**
Module -3 **Aircraft Management Maintenance** Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control centre flight line (preflight & post flight), Aircraft Logbook, Maintenance crew skill requirements	**8 Hours**	**L1, L2, L3**
Module -4 **Hanger Maintenance (on Aircraft) & Material Support** Introduction, organization of hanger maintenance, Non- routine item, parts availability, cannibalization, Types of shops- sheet metal shop, Aircraft interior shop, Engine shop, Avionics shop, ground support equipment, outsourcing of shop maintenance work, operation of overhaul shops, Material support, Material management inventory control, Support functions of material, Parts ordering, Storage, Issue, control and handling, Parts receiving quality control, calibration program, stock level adjustments, shelf life, exchanges, warranty & modifications of parts.	**10 Hours**	**L1, L2, L3**
Module -5 **Maintenance Safety & Trouble shooting** Safety regulations, occupational safety and health standards maintenance safety program, Airlines safety management, General safety rules, Accident & injury reporting, Hazardous materials storage and handling aircraft furnishing practices trouble shooting, Knowledge of malfunctions.	**10 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Maintain the aircraft maintenance manual and logbook.
2. Do the quality control and calibration.
3. Incorporate the safety regulations and rules.

Graduate Attributes (as per NBA):

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Harry A Kinnison, Tariq Siddiqui, Aviation Maintenance Management, Mc Graw Hill education (India) Private Ltd 2013.
2. Kroes, Watkins, Delp, ‘Aircraft maintenance and repair’, Mc Graw Hill, 2013.

Reference Books:

1. Larry Reithmaier " Aircraft Repair Manual" Palmar Books, Marquette, 1992.
2. Brimm. DJ, Bogges, HE, Aircraft Maintenance, Pitman publishing corp, London, 1952.

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AIRCRAFT PROPULSION LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VI

Subject Code	**17AEL67**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course Objectives: This course will enable students to

1. Understand how to do the heat transfer
2. Comprehend the cascade testing of axial compressor and axial turbine blade row.
3. Study the performance of propeller and jet engines.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
1. Study of an aircraft piston engine. (Includes study of assembly of sub systems, various components, their functions and operating principles)	**L1, L2, L3, L4**
2. Study of an aircraft jet engine (Includes study of assembly of sub systems, various components, their functions and operating principles)	**L1, L2, L3, L4**
3. Study of forced convective heat transfer over a flat plate.	**L1, L2, L3, L4**
4. Cascade testing of a model of axial compressor blade row.	**L1, L2, L3, L4**
5. Cascade testing of a model of axial Turbine blade row	**L1, L2, L3, L4, L5**
6. Study of performance of a propeller.	**L1, L2, L3, L4**
7. Determination of heat of combustion of aviation fuel.	**L1, L2, L3, L4**
8. Study of free and wall jet	**L1, L2, L3**
9. Measurement of burning velocity of a premixed flame.	**L1, L2, L3**
10. Study of the flame lift up and fall back phenomenon for varied Air/Fuel ratio.	**L1, L2, L3**
11. Measurement of nozzle flow.	**L1, L2, L3**
12. Performance studies on a scaled jet engine	**L1, L2, L3**

13. Study of free convective heat transfer over a flat plate	**L1, L2, L3**
14. Study of Fuel injection characteristics	**L1, L2, L3**

Course Outcomes:
After studying this course, students will be able to:
1. Analyze the cascade testing of axial compressor and axial turbine blade row.
2. Evaluate the performance of a jet engine.
3. Perform the measurement of a flame and nozzle flow.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

AIRCRAFT STRUCTURES LAB

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VI

Subject Code	**17AEL68**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course Objectives: This course will enable students to

1. Learn about the simply supported beam, cantilever beam.
2. Understand the Maxwell's theorem and Poisson ration.
3. Acquire the knowledge about buckling load, shear failure and shear centre.

Modules	Revised Bloom's Taxonomy (RBT) Level
1. Deflection of a Simply Supported Beam.	**L1, L2, L3, L4**

2. Deflection of a cantilever Beam	**L1, L2, L3, L4**
3. Beam with combined loading by using superposition theorem	**L1, L2, L3, L4**
4. Verification of Maxwell's Reciprocal Theorem.	**L1, L2, L3, L4**
5. Determination of Young's Modulus using strain gages.	**L1, L2, L3, L4, L5**
6. Poisson Ratio Determination	**L1, L2, L3, L4**
7. Buckling load of slender Eccentric Columns and Construction of Southwell Plot	**L1, L2, L3, L4**
8. Shear Failure of Bolted and Riveted Joints	**L1, L2, L3**
9. Bending Modulus of sandwich Beam	**L1, L2, L3**
10. Fault detection and de-lamination studies in composite plate	**L1, L2, L3**
11. Determination of fundamental frequency and spectrum analysis of a cantilever beam and harmonics.	**L1, L2, L3**
12. Vibration induced structural damage studies	**L1, L2, L3**
13. Determining of Shear centre location for open sections-unsymmetrical bending	**L1, L2, L3**
14. Determining of Shear centre location for closed sections	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Compute the deflection of simply supported beam and cantilever beam.
2. Verify the Maxwell's theorem.
3. Determine the buckling load, shear failure and shear centre.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

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SCHEME OF TEACHING AND EXAMINATION 2017-2018

Aeronautical Engineering

VII Semester

S. No	Subject Code	Title	Teaching Hours /Week		Examination				Credits
			Theory	Practical/Drawing	Duration	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	17AE71	CONTROL ENGINEERING	04		03	60	40	100	4
2	17AE72	COMPUTATIONAL FLUID DYNAMICS	04		03	60	40	100	4
3	17AE73	AIRCRAFT STABILITY AND CONTROL	04		03	60	40	100	4
4	17AE74X	PROFESSIONAL ELECTIVE	03		03	60	40	100	3
5	17AE75X	PROFESSIONAL ELECTIVE	03		03	60	40	100	3
6	17AEL76	FLIGHT SIMULATION LAB		1I+2P	03	60	40	100	2
7	17AEL77	MODELING AND ANALYSIS LAB		1I+2P	03	60	40	100	2
8	17AEP78	Project Phase –I + Project Seminar	-	03	-	-	100	100	2
TOTAL			**18**	**9**	**21**	**420**	**380**	**800**	**24**

Professional Elective (17AE74X)		Professional Elective (17AE75X)	
17AE741	FATIGUE AND FRACTURE MECHANICS	17AE751	OPERATIONS RESEARCH
17AE742	HIGH PERFORMANCE COMPUTING	17AE752	WIND TUNNEL TECHNIQUES
17AE743	HELICOPTER DYNAMICS	17AE753	NUMERICAL METHODS
17AE744	AERO-ELASTICITY	17AE754	GUIDANCE, NAVIGATION & CONTROL

1. Core subject: This is the course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2. Professional Elective: Elective relevant to chosen specialization/ branch

3. Project Phase –I + Project Seminar: Literature Survey, Problem Identification, objectives and Methodology. Submission of synopsis and seminar.

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SCHEME OF TEACHING AND EXAMINATION 2017-2018

CONTROL ENGINEERING

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	**17AE71**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

4. Understand the basic concepts of control systems and mathematical models.
5. Acquire the knowledge on block diagrams and signal flow graphs.
6. Understand the frequency response analysis and various types of plots.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction to Control Systems and Mathematical Models** **Introduction:** Concept of controls, Open loop and closed loop systems with examples, Concepts of feedback and basic structure of feedback control system, requirements of an ideal control system. **Mathematical Models:** Transfer function models of mechanical systems, electrical circuits, DC and AC motors in control systems, Analogous systems: Force voltage and Force current analogy.	**10 Hours**	**L1, L2**
Module -2 **Block Diagrams and Signal Flow Graphs** Transfer functions definition and its properties, block representation of control systems and terminologies, block diagram algebra and reduction of block diagrams, Signal flow graph method, Mason's gain formula and its applications **Transient and Steady State Response Analysis** Introduction, type and order of systems, time response specifications, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its importance in speed of response.	**10 Hours**	**L1, L2**
Module -3 **System stability** analysis using Routh's – Hurwitz Criterion **Root Locus Plots** Definition of root loci, General rules for constructing root loci, Analysis using root locus plots, Determination of desired gain, limit gain, gain margin and conditional stability.	**10 Hours**	**L1, L2, L3**

Frequency Response Analysis Using Bode Plots: Bode attenuation diagrams for first and second order systems, Simplified Bode diagrams, Stability analysis using Bode plots and determination of phase margin and gain margin and gain .		
Module -4 **Frequency Response Specification and Analysis using Polar plots:** **Specification:** Frequency response definition, frequency response specifications and its relationship with time response specifications. **Analysis:** Polar plots, Nyquist stability criterion, Stability analysis, Relative stability concepts, Gain margin and phase margin, M&N circles.	**10 Hours**	**L1, L2, L3**
Module -5 **Feedback control systems:** Types of controllers – Proportional, Integral, Derivative controllers, Proportional – Integral, Proportional – Integral – Derivative controllers; Compensation methods – Series and feedback compensation, Lead, Lag and Lead-Lag Compensators. **State Variable Characteristics of Linear Systems:** Introduction to concepts of states and state variable representation of linear systems, Advantages and Disadvantages over conventional transfer function representation, state equations of linear continuous data system. Matrix representation of state equations, Solution of state equation, State transition matrix and its properties, controllability and observability, Kalman and Gilberts test.	**10 Hours**	**L1, L2, L3**

Course Outcomes:
After studying this course, students will be able to:
4. Apply the concepts of control systems.
5. Reduce the block diagrams and signal flow graphs.
6. Determine the frequency response analysis by using various types of plots.

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. U.A. Bakshi and V.U. Bakshi, Control Engineering, Technical Publications, ISBN: 978-93-5099-657-7.
2. A. Nagoor Kani, Control Systems Engineering, RBA Publications, 2014.

Reference Books:

1. Katsuhiko Ogatta, Modern Control Engineering, Pearson Education,2004.
2. I.J. Nagrath and M. Gopal, Control Systems Engineering, New Age Publishers, 2017.
3. Richard. C. Dorf and Robert.H. Bishop, Modern Control Systems, Addison Wesley, 1999.
4. N.S. Nise, Control Systems Engineering, 6^{th} Edition, Wiley, 2012.

COMPUTATIONAL FLUID DYNAMICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	**17AE72**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Know the basic equations of fluid dynamics, boundary layer and discretization.
2. Understand the source and vortex panel method.
3. Know about FDM, FVM and FEM.

Modules	Teaching Hours	Revised Bloom's Taxonomy Level
Module -1 **Introduction:** CFD Applications. Need for Parallel Computers in CFD algorithms. Models of flows. Substantial derivative, Divergence of velocity. Continuity, Momentum, and Energy Equations-Derivation in various forms. Integral versus Differential form of equations. Comments on governing equations. Physical boundary conditions. Forms of equations especially suitable for CFD work. Shock capturing, and shock fitting.	**10 Hours**	**L1, L2**
Module -2 **Mathematical Behaviour of Partial Differential Equations:** Classification of partial differential equations. Cramer Rule and Eigen value methods for classification. Hyperbolic, parabolic, and elliptic forms of equations. Impact of classification on physical and computational fluid dynamics. Case studies: steady inviscid supersonic flow, unsteady inviscid flow, steady boundary layer flow, and unsteady thermal conduction, steady subsonic inviscid flow.	**10 Hours**	**L1, L2**

Module -3 **Grid Generation and Adaptive Grids:** Need for grid generation and Body-fitted coordinate system. Structured Grids-essential features. Structured Grid generation techniques- algebraic and numerical methods. Unstructured Grids-essential features. Unstructured Grid generation techniques- Delaunay-Voronoi diagram, advancing front method. Surface grid generation, multi-block grid generation, and meshless methods. Grid quality and adaptive grids. Structured grids adaptive methods and unstructured grids adaptive methods.	**10 Hours**	**L1, L2, L3**
Module -4 **Discretisation & Transformation:** Discretisation: Finite differences methods, and difference equations. Explicit and Implicit approaches. Unsteady Problem -Explicit versus Implicit Scheme. Errors and stability analysis. Time marching and space marching. Reflection boundary condition. Relaxation techniques. Alternating direction implicit method. Successive over relaxation/under relaxation. Second order Lax-Wendroff method, mid-point Leap frog method, upwind scheme, numerical viscosity, and artificial viscosity. **Transformation:** Transformation of governing partial differential equations from physical domain to computational domain. Matrices and Jacobians of transformation. Example of transformation. Generic form of the Governing flow equations in Strong Conservative form in the Transformed Space.	**10 Hours**	**L1, L2**
Module -5 **Finite Volume Technique and Some Applications:** Spatial discretisation- cell centered and cell vertex techniques (overlapping control volume, duel control volume). Temporal discretisation- Explicit time stepping, and implicit time stepping. Time step calculation. Upwind scheme and high resolution scheme. Flux vector splitting, approximate factorisation. Artificial dissipation and flux limiters. Unsteady flows and heat conduction problems. Upwind biasing.	**10 Hours**	**L1, L2**

Course outcomes:

After studying this course, students will be able to:

1. Differentiate the FDM, FVM and FEM
2. Perform the flow, structural and thermal analysis.
3. Utilize the discretization methods according to the application.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics", Springer, Berlin,2nd edition, 2002,ISBN-13: 978-3540543046
2. John D. Anderson, "Computational Fluid Dynamics", McGraw Hill, 2013, **ISBN-13:** 978-0070016859.

Reference Books:

1. John F. Wendt, "Computational Fluid Dynamics - An Introduction", Springer, 3rd Edition, 2013
2. Charles Hirsch, "Numerical Computation of Internal and External Flows", Elsevier,1st edition, 2007, ISBN-13: 978-9381269428.
3. Klaus A Hoffmann and Steve T. Chiang. "Computational Fluid Dynamics for Engineers", Vols. I & II Engineering Education System, 1993.
4. Tapan K. Sengupta, Fundamentals of CFD, Universities Press, 2004.

AIRCRAFT STABILITY AND CONTROL

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	**17AE73**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the basics of aircraft stability and control.
2. Understand the static longitudinal and static directional stability.
3. Acquire the knowledge on dynamic lateral and directional stability.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Static Longitudinal Stability and Control-Stick Fixed** Historical perspective, Aerodynamic Nomenclature, Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- Propeller airplane and Jet airplane Introduction, Trim condition. Static margin. stick fixed neutral points. Longitudinal control, Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator	**10 Hours**	**L1, L2**

required for landing, Restriction on forward C.G. range.		
Module -2 **Static Longitudinal Stability& Static Directional Stability and Control-Stick free** Introduction, Hinge moment parameters, Control surface floating characteristics and aerodynamic balance, Estimation of hinge moment parameters, The trim tabs, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G. Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin. One engine inoperative condition. Weather cocking effect.	**10 Hours**	**L1, L2**
Module -3 **Static lateral dynamic & longitudinal stability and control** Introduction, definition of Roll stability. Estimation of dihedral effect., Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, Balancing the aileron. Coupling between rolling and yawing moments. Adverse yaw effects. Aileron reversal. Definition of Dynamic longitudinal stability. Types of modes of motion: long or phugoid motion, short period motion. Airplane Equations of longitudinal motion.	**10 Hours**	**L1, L2, L3**
Module -4 **Estimation of Dynamic Derivatives** Derivation of rigid body equations of motion, Orientation and position of the airplane, gravitational and thrust forces, Small disturbance theory. Aerodynamic force and moment representation, Derivatives due to change in forward speed,	**10 Hours**	**L1, L2, L3**

Derivatives due to the pitching velocity, Derivatives due to the time rate of change of angle of attack, Derivatives due to rolling rate, Derivatives due to yawing rate.		
Module -5 **Dynamic Lateral and Directional Stability** Routh's criteria. Factors affecting period and damping of oscillations. Effect of wind shear. Flying qualities in pitch. Cooper-Harper Scale. Response to aileron step-function, side-slip excursion. Dutch roll and Spiral instability. Auto- rotation and spin. Stability derivatives for lateral and directional dynamics.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts of aircraft stability and control.
2. Differentiate the static longitudinal and static directional stability.
3. Estimate the dynamic derivatives.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley Son Inc, New York, 1988.
2. Nelson, R.C. "Flight Stability and Automatic Control", McGraw-Hill Book Co., 2007.

Reference Books:

1. Bandu N. Pamadi, `Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill, International Editions, Aerospace Science Technology Editions, 2000.
3. W.J. Duncan, The Principles of the Control and Stability of Aircraft, Cambridge University Press, 2016.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2017-2018

PROFESSIONAL ELECTIVES

FATIGUE AND FRACTURE MECHANICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

Subject Code	**17AE741**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objective:
This course will enable students to

1. Understand the basics of fatigue of structures.
2. Comprehend the fracture mechanics.
3. Acquire the knowledge of fatigue design and testing.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Fatigue of Structures:** S.N. curves, Endurance limit, Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams, Notches and stress concentrations, Neuber's stress concentration factors, plastic stress concentration factors – Notched S-N curves.	**10 Hours**	**L1, L2**
Module -2 **Statistical Aspects of Fatigue Behaviour:** Low cycle and high cycle fatigue, Coffin-Manson's relation, Transition life, Cyclic Strain hardening and softening, Analysis of load histories, Cycle counting techniques, Cumulative damage, Miner's theory, other theories.	**8 Hours**	**L1, L2**
Module -3 **Physical Aspects of Fatigue:** Phase in fatigue life, Crack initiation, Crack growth, Final fracture, Dislocations, Fatigue fracture surfaces.	**6 Hours**	**L1, L2, L3**
Module -4 **Fracture Mechanics:** Strength of cracked bodies, potential energy and surface energy, Griffith's theory, Irwin – Orwin extension of Griffith's theory to ductile materials, Stress analysis of cracked bodies, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries.	**8 Hours**	**L1, L2**
Module -5 **Fatigue Design and Testing:** Safe life and fail safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application to	**8 Hours**	**L1, L2**

composite materials and structures.		

Course outcomes:
After studying this course, students will be able to:
1. Evaluate the fatigue of structures.
2. Determine the strength of cracked bodies.
3. Distinguish the safe life and fail safe design.

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. D. Brock, “Elementary Engineering Fracture Mechanics”, Noordhoff International Publishing Co., London, 1994.
2. J.F. Knott, “Fundamentals of Fracture Mechanics”, Butterworth & Co., Publishers Ltd., London,1983.

Reference Books:

1. W. Barrois and L. Ripley, “Fatigue of Aircraft Structures”, Pergamon Press, Oxford, 1983.
2. C.G.Sih, “Mechanics of Fracture”, Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

HIGH PERFORMANCE COMPUNTING

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII

Subject Code	**17AE742**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objective:
This course will enable students to
1. Understand the concepts of high performance computing
2. Acquire the knowledge of various algorithms required for parallel computing.
3. Understand the concepts of architecture.

		Revised

Modules	Teaching Hours	Bloom's Taxonomy (RBT) Level
Module -1 **Computational Science and Engineering Introduction**: Computational Science and Engineering Applications; characteristics and requirements, Review of Computational Complexity, Performance: metrics and measurements, Granularity and Partitioning, Locality: temporal/spatial/stream/kernel, Basic methods for parallel programming, Real-world case studies (drawn from multi-scale, multi-discipline applications)	8 Hours	L1, L2
Module -2 **High-End Computer Systems: Memory Hierarchies, Multi-core Processors**: Homogeneous and Heterogeneous, Shared-memory Symmetric Multiprocessors, Vector Computers, Distributed Memory Computers, Supercomputers and Petascale Systems, Application Accelerators / Reconfigurable Computing, Novel computers: Stream, multithreaded, and purpose-built.	8 Hours	L1, L2
Module -3 **Parallel Algorithms**: Parallel models: ideal and real frameworks, Basic Techniques: Balanced Trees, Pointer Jumping, Divide and Conquer, Partitioning, Regular Algorithms: Matrix operations and Linear Algebra, Irregular Algorithms: Lists, Trees, Graphs, Randomization: Parallel Pseudo-Random Number Generators, Sorting, Monte Carlo techniques.	8 Hours	L1, L2, L3
Module -4 **Parallel Programming**: Revealing concurrency in applications, Task and Functional Parallelism, Task Scheduling, Synchronization Methods, Parallel Primitives (collective operations), SPMD Programming (threads, Open MP, MPI), I/O and File Systems, Parallel Matlabs (Parallel Matlab, Star-P, Matlab MPI), Partitioning Global Address Space (PGAS) languages (UPC, Titanium, Global Arrays).	8 Hours	L1, L2
Module -5 **Achieving Performance**: Measuring performance, identifying performance bottlenecks, Restructuring applications for deep memory hierarchies, Partitioning applications for heterogeneous resources, Using existing libraries, tools, and frameworks.	8 Hours	L1, L2
Course outcomes: After studying the course the students will be able to 1. Apply the concepts of high performance computing 2. Develop various algorithms required for parallel computing.		

3. Compare architectures for high performance computing.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Modern tools

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Grama, A. Gupta, G. Karypis, V. Kumar, An Introduction to Parallel Computing, Design and Analysis of Algorithms, Pearson Education India,2nd edition, 2004,ISBN-13: 978-8131708071.
2. G.E. Karniadakis, R.M. Kirby II, Parallel Scientific Computing in C++ and MPI: A Seamless Approach to Parallel Algorithms and their Implementation, Cambridge University Press, 2003.

Reference Books:

1. Wilkinson and M. Allen, Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers, Pearson,2nd edition, 2006, ISBN-13: 978-8131702390.
2. M.J. Quinn, Parallel Programming in C with MPI and Open MP, McGraw-Hill, 1st edition,2003, ISBN-13: 978-0070582019.
3. G.S. Almasi and A. Gottlieb, Highly Parallel Computing, 2/E, Addison-Wesley, 1994.
4. J. Dongarra, I. Foster, G. Fox, W. Gropp, K. Kennedy, L. Torczon, A. White, editors, The Sourcebook of Parallel Computing, Morgan Kaufmann, 2002.

AEROELASTICITY

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

Subject Code	**17AE744**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objective:

This course will enable students to

1. Understand the basic aero elastic phenomena.
2. Comprehend the steady state aero elastic problems and flutter phenomena.
3. Acquire the knowledge on the aero elastic problems.

Modules	Teaching	Revised Bloom’s

	Hours	Taxonomy (RBT) Level
Module -1 **Aeroelastic Phenomena**: Stability versus response problems, The aeroelastic triangle of forces, Aeroelasticity in Aircraft Design, Prevention of aeroelastic instabilities. Influence and stiffness coefficients. Flexure, torsional oscillations of beam, Differential equation of motion of beam.	**8 Hours**	**L1, L2**
Module -2 **Divergence of a Lifting Surface:** Simple two dimensional idealizations -Strip theory – Integral equation of the second kind – Exact solutions for simple rectangular wings – 'Semi rigid' assumption and approximate solutions – Generalized coordinates – Successive approximations – Numerical approximations using matrix equations.	**8 Hours**	**L1, L2**
Module -3 **Steady State Aeroelastic Problems:** Loss and reversal of aileron control – Critical aileron reversal speed – Aileron efficiency – Semi rigid theory and successive approximations – Lift distribution – Rigid and elastic wings. Tail efficiency. Effect of elastic deformation on static longitudinal stability.	**8 Hours**	**L1, L2, L3**
Module -4 **Flutter Phenomenon**: Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasi steady aerodynamic derivatives. Galerkin method for critical flutter speed – Stability of disturbed motion – Solution of the flutter determinant – Methods of determining the critical flutter speeds – Flutter prevention and control.	**9 Hours**	**L1, L2**
Module -5 **Examples of Aeroelastic Problems**: Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges.	**7 Hours**	**L1, L2**

Course outcomes:

After studying this course, students will be able to:

1. Apply the aero elastic phenomena.
2. Evaluate the steady state aero elastic problems and flutter phenomena.
3. Classify the types of aero elastic problems.

Graduate Attributes:

- Engineering Knowledge.

- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", Dover Publications Inc, 2008, ISBN-13: 978-0486469362
2. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd., 1986

Reference Books:

1. R.L. Bisplinghoff, H. Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 1996.
2. R.H. Scanlan and R. Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan Co., New York, 1981.
3. R.D. Blevins, "Flow Induced Vibrations", Krieger Pub Co., 2001

HELICOPTER DYNAMICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

Subject Code	**17AE743**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the basic concepts of helicopter dynamics.
2. Acquire the knowledge of critical speed and rotor bearing system.
3. Understand the turborotor system and blade vibration.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction:** History of helicopter flight. Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust and power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation. **Blade Element Analysis:** Blade element analysis in hovering	**8 Hours**	**L1, L2**

and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, lead/lag hinge, and drag hinge.		
Module -2 **Basic Helicopter Performance**: Forces acting on helicopters in forward flight. Methods of achieving translatory flight. Controlling cyclic pitch: Swash-plate system. Lateral tilt with and without conning. Lateral and longitudinal asymmetry of lift in forward flight. Forward flight performance- total power required, effects of gross weight, effect of density altitude. Speed for minimum power, and speed for maximum range. Factors affecting forward speed, and ground effects.	**8 Hours**	**L1, L2**
Module -3 **Rotor Airfoil Aerodynamics:** Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range. **Rotor Wakes and Blade Tip Vortices:** Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake.	**8 Hours**	**L1, L2, L3**
Module -4 **Helicopter Stability and Control.** Introductory concepts of stability. Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional and directional. Dynamic stability aspects. Main rotor and tail rotor control. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, Levels of handling qualities. **Flight Testing**- General handing flight test requirements and, basis of limitations.	**8 Hours**	**L1, L2, L3**
Module -5 **Standards, and Specifications:** Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification. **Conceptual Design of Helicopters:** Overall design requirements. Design of main rotors-rotor diameter, tip speed, rotor solidity, blade twist and aerofoil selection, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft.	**8 Hours**	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:
1. Apply the basic concepts of helicopter dynamics.
2. Compute the critical speed by using various methods.
3. Distinguish the turborotor system stability by using transfer matrix and finite element formulation.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. J. Gordon Leishman, Principles of Helicopter Aerodynamics, Cambridge University Press, 2002.
2. George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons, Inc, NY,1975.

Reference Books:

1. W Z Stepniewski and C N Keys, Rotary Wing Aerodynamics, Dover Publications, Inc, New York, 1984.
2. ARS Bramwell, George Done, and David Balmford, Helicopter Dynamics, 2nd Edition, Butterworth-Heinemann Publication, 2001.
3. John, M. Seddon and Simon Newman, Basic Helicopter Aerodynamics, Wiley, 2011.
4. Gareth D. Padfield, Helicopter Flight Dynamics, 2nd Edition, Wiley, 2011.

OPERATIONS RESEARCH

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

Subject Code	**17AE751**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objective:
This course will enable students to

1. Understand the basic of operations research.

2. Comprehend the PERT-CPM techniques, queuing theory and game theory.
3. Acquire the knowledge on sequencing.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction**: Evolution of OR, definition of OR, scope of OR, application areas of OR, steps (phases) in OR study, characteristics and limitations of OR, models used in OR, linear programming (LP) problem-formulation and solution by graphical method. **Solution Of Linear Programming Problems**: The simplex method-canonical and standard form of an LP problem, slack, surplus and artificial variables, big M method and concept of duality, dual simplex method.	**9 Hours**	**L1, L2**
Module -2 **Transportation Problem:** Formulation of transportation problem, types, initial basic feasible solution using different methods, optimal solution by MODI method, degeneracy in transportation problems, application of transportation problem concept for maximization cases. Assignment Problem-formulation, types, application to maximization cases and travelling salesman problem	**7 Hours**	**L1, L2**
Module -3 **Integer Programming:** Pure and mixed integer programming problems, solution of Integer programming problems-Gomory's all integer cutting plane method and mixed integer method, branch and bound method, Zero-One programming. **Pert-CPM Techniques:** Introduction, network construction - rules, Fulkerson's rule for numbering the events, AON and AOA diagrams; Critical path method to find the expected completion time of a project, floats; PERT for finding expected duration of an activity and project, determining the probability of completing a project, predicting the completion time of project; crashing of simple projects	**8 Hours**	**L1, L2, L3**
Module -4 **Queuing Theory:** Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), empirical queuing models – M/M/1 and M/M/C models and their steady state performance analysis. **Game Theory:** Formulation of games, types, solution of games with saddle point, graphical method of solving mixed strategy games, dominance rule for solving mixed strategy games.	**9 Hours**	**L1, L2**
Module -5 **Sequencing:** Basic assumptions, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing	**7 Hours**	**L1, L2**

2 jobs on 'm' machines using graphical method.

Course outcomes:

After studying this course, students will be able to:

1. Apply the basic of operations research.
2. Classify the PERT-CPM techniques, queuing theory and game theory.
3. Identify the sequencing techniques.

Graduate Attributes :

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. P K Gupta and D S Hira, Operations Research, Chand Publications, New Delhi, Revised edition, 2007, ISBN-13: 978-8121902816
2. Taha H A ,Operations Research, Pearson Education,9th edition,2014,ISBN-13: 978-9332518223

Reference Books:

1. A P Verma, Operations Research, S K Kataria &Sons, 2012, ISBN-13: 978-9350142400
2. Paneerselvan, Operations Research, PHI,2nd edition,2009, ISBN-13: 978-8120329287
3. A M Natarajan, P Balasubramani, Operations Research, Pearson Education, 1st edition,2011, ISBN-13: 978-8131767764
4. Hillier and Liberman, Introduction to Operations Research, 8th Ed., McGraw Hill
5. S.D. Sharma , Operations Research, , Kedarnath Ramanath & Co, 2012.

WIND TUNNEL TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Professional Elective

Subject Code	**17AE752**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objective:
This course will enable students to
1. Understand the basic of wind tunnel testing.
2. Understand the types and functions of wind tunnel.
3. Acquire the knowledge on conventional measurement techniques and special wind tunnel techniques.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Principles Of Model Testing**: Buckingham Theorem, Non dimensional numbers, Scale effect, Geometric Kinematic and Dynamic similarities.	8 Hours	L1, L2
Module -2 **Types And Functions Of Wind Tunnels**: Classification and types, special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions, Layouts, sizing and design parameters.	7 Hours	L1, L2
Module -3 **Calibration Of Wind Tunnels**: Test section speed, Horizontal buoyancy, Flow angularities, Flow uniformity & turbulence measurements, Associated instrumentation, Calibration of subsonic & supersonic tunnels.	8 Hours	L1, L2, L3
Module -4 **Conventional Measurement Techniques**: Force measurements and measuring systems, Multi component internal and external balances, Pressure measurement system, Steady and Unsteady Pressure, single and multiple measurements, Velocity measurements, Intrusive and Non-intrusive methods, Flow visualization techniques, surface flow, oil and tuft, flow field visualization, smoke and other optical and nonintrusive techniques.	9 Hours	L1, L2
Module -5 **Special Wind Tunnel Techniques**: Intake tests, store carriage and separation tests, Unsteady force and pressure measurements, wind tunnel model design.	8 Hours	L1, L2

Course outcomes:
After studying this course, students will be able to:
1. Apply the principles and procedures for model testing in the wind tunnel.
2. Classify the types and functions of wind tunnel.
3. Distinguish the conventional measurement techniques and special wind tunnel techniques.

Graduate Attributes:
- Engineering Knowledge.

- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Rae, W.H. and Pope, A., "Low Speed Wind Tunnel Testing", John Wiley Publication, 3rd edition, 2010, ISBN-13: 978-8126525683.
2. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.

Reference Books:

1. **E. Rathakrishnan, Instrumentation, Measurements, and Experiments in Fluids, CRC Press, 2007.**
2. Bradsaw "Experimental Fluid Mechanics", Pergamon Press, 2nd Revised edition,1970, ISBN-13: 978-0080069814
3. Short term course on Flow visualization techniques, NAL, 2009
4. Lecture course on Advanced Flow diagnostic techniques, NAL.
5. NAL-UNI Lecture Series 12:" Experimental Aerodynamics", NAL SP 98 01 April 1998

NUMERICAL METHODS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

Subject Code	**17AE753**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the basic concepts of numerical methods.
2. Acquire the knowledge of interpolation and approximation.
3. Understand about the curve fitting, root finding and optimization.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level

Module	Hours	Levels
Module -1 **Numerical Computation** Motivation and Objectives/ Number Representation/ Machine Precision/ Round-of Error/ Truncation Error/ Random Number Generation. **Linear Algebraic Systems:** Motivation and Objectives/ Gauss-Jordan Elimination/Gaussian Elimination/LU Decomposition/ III-Conditioned Systems/ Iterative Methods.	**6 Hours**	**L1, L2**
Module -2 **Interpolation and Approximation** Lagrangian Polynomials - Divided differences Interpolating with a cubic spline - Newton's forward and backward difference formulas. **Eigen Values and Eigenvectors** Motivation and Objectives/ The characteristics Polynominal/ Power Methods / Jacobi's Method/ Householder Transformation/ QR Method/ Danilevsky's Method/ Polynominal Roots.	**6 Hours**	**L1, L2**
Module -3 **Numerical Differentiation and Integration** Derivative from difference tables - Divided differences and finite differences - Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rules - Two and Three point Gaussian quadrature formulas - Double integrals using trapezoidal and Simpson's rules.	**8 Hours**	**L1, L2, L3**
Module -4 **Curve Fitting** Motivation and objectives/ Interpolation/ Newton's Difference Formula/ Cubic Splines/ Least Square/ Two-Dimensional Interpolation.	**10 Hours**	**L1, L2, L3**
Module -5 **Root Finding** Motivation and Objectives/ Bracketing methods/ Contraction Mapping Method/ Secant Method/ Muller's Method/ Newton's Method/ Polynomial Roots/ Nonlinear Systems of Equations. **Optimization** Motivation and Objectives/ Local and Global Minima/ Line Searches/ Steepest Descent Method/ Conjugate-Gradient Method/ Quasi-Newton Methods/ Penalty Functions/ Simulated Annealing.	**10 Hours**	**L1, L2, L3**

Course outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts of numerical methods.
2. Compute the Eigen values, Eigen vectors, numerical differentiation and integration.
3. Perform the curve fitting and root finding.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Robert Schilling and Sandra Harris, Applied Numerical methods for Engineers Using Mat Lab and C- Thomson Learning, 2002.
2. Gerald and Wheatley, Applied Numerical Analysis –Pearson Education, 2002.

Reference Books:

1. Mahinder Kumar Jain, Numerical Methods: For Scientific and Engineering Computation, New Age Publishers, 2012.
2. Rajesh Srivastava and Saumyen Guha, Numerical Methods for Engineering and Science, Oxford University Press, 2010.
3. P. Kandasamy, K. Thilagavathy and K. Gunavathi, Numerical Methods, S. Chand Publishers, 2006.

GUIDANCE, NAVIGATION & CONTROL

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VII
Professional Elective

Subject Code	**17AE754**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60
CREDITS – 03			

Course Objectives: This course will enable students to

1. Comprehend the basic concepts of navigation, guidance and control.
2. Acquire the knowledge of radar systems and other guidance systems.
3. Understand the missile guidance and control system.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction** Concepts of navigation, guidance and control. Introduction to basic principles. Air data information. **Radar Systems** Principle of working of radar. MTI and Pulse Doppler radar. Moving target detector. Limitation of MTI performance. MTI from a moving platform (AMTI).	**6 Hours**	**L1, L2**
Module -2 **Tracking with Radar** Mono pulse tracking. Conical scan and sequential lobbing. Automatic tracking with surveillance radar (ADT). **Other Guidance Systems** Gyros and stabilized platforms. Inertial guidance and Laser based guidance. Components of Inertial Navigation System. Imaging Infrared guidance. Satellite navigation. GPS.	**6 Hours**	**L1, L2**
Module -3 **Transfer Functions** Input-output Transfer function. Basic altitude reference. Concepts of Open loop and Close Loop. **Missile Control System** Guided missile concept. Roll stabilization. Control of aerodynamic missile. Missile parameters for dynamic analysis. Missile autopilot schematics. Acceleration command and root locus.	**8 Hours**	**L1, L2, L3**
Module -4 **Missile Guidance** Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance	**10 Hours**	**L1, L2, L3**
Module -5	**10 Hours**	**L1, L2, L3**

Integrated Flight/Fire Control System Director fire control system. Tracking control laws. Longitudinal flight control system. Lateral flight control system. Rate of change of Euler angle, Auto Pilot.		

Course outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts of navigation, guidance and control.
2. Compare the different types of missile guidance system performance.
3. Integrate the flight and fire control system.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. P.T. Kabamba and A.R. Girard, Fundamentals of Aerospace Navigation and Guidance, Cambridge Aerospace Series, 2014.

2. John H Blakelock, ` Automatic control of Aircraft & Missiles`, Wile –Inter Science Publication, 2nd edition, May 1990.

Reference Books:

1. R.B. Underdown & Tony Palmer, `Navigation`, Black Well Publishing; 2001.
2. Merrilh I. Skolnik, ` Introduction to Radar Systems`, 3rd edition, Tata Mc Graw Hill, 2001.
3. George M. Siouris, Missile Guidance and Control Systems, Springer, 2004.

FLIGHT SIMULATION LAB [As per Choice Based Credit System (CBCS) scheme] SEMESTER – VII			
Subject Code	**17AEL76**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60
CREDITS – 02			

Course Objectives: This course will enable students to

- Understand the root locus and bode plot.
- Understand the spring mass damper system and the servo mechanism system with feedback.
- Acquire the knowledge to use computational tools to model aeronautical vehicle dynamics.

Modules	**Revised Bloom's Taxonomy (RBT) Level**
15. Draw Pole-Zero map of dynamic system model with plot customization option	**L1, L2, L3**
16. Plot root locus with variables in transfer function through MATLAB	**L1, L2, L3**
17. Plot root locus for a dynamic system though MATLAB	**L1, L2, L3**
18. Draw Bode plot from a transfer function in MATLAB and explain the gain and phase margins	**L1, L2, L3, L4**

19. Simulate a spring- mass- damper system with and without a forcing function though SIMULINK	**L1, L2, L3**
20. Simulate a simple servo-mechanism motion with feedback- in the time domain, and in \`s\` domain	**L1, L2, L3**
21. Simulate a bomb drop from an aircraft on a moving tank in pure pursuit motion	**L1, L2, L3**
22. Develop a straight and level flight simulation program using MATLAB	**L1, L2, L3**
23. Simulate aircraft Take-off and Landing with trajectory tracing	**L1, L2, L3**
24. Simulate stall of aircraft and show the effect of variation in static margin on stalling characteristics	**L1, L2, L3**
25. Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a pulse input in pitch that is intended to bleed the airspeed.	**L1, L2, L3**
26. Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a doublet input in pitch	**L1, L2, L3**
27. Given a Quartic characteristic equation, determine two quadratics that shall result in poles of short-period oscillations and poles of Phugoid. Vary the coefficients of polynomial to study the movement of poles.	**L1, L2, L3**
28. Given a Quartic characteristics equitation, determine Poles and Time constants for Roll mode, Spiral motion, and Dutch roll. Vary the coefficients of polynomial to study the movement of poles.	**L1, L2, L3**

Course outcomes:
After studying this course, students will be able to:

1. Plot the root locus and bode plot.
2. Calculate the dynamics response of aircraft.
3. Use computational tools to model aircraft trajectory.

Conduct of Practical Examination:

9. All laboratory experiments are to be included for practical examination.
10. Students are allowed to pick one experiment from the lot.
11. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
12. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions (partly)
- Interpretation of data.

MODELING & ANALYSIS LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VII

Subject Code	**17AEL77**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	42	Exam Marks	60

CREDITS – 02

Course Objectives: This course will enable students to

- Understand the procedure to draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
- Acquire the knowledge of types of meshing.
- Understand the basics of flow and stress analysis.

Modules	Revised Bloom's Taxonomy (RBT) Level
1. Modeling of Symmetrical/Cambered Aerofoil Geometry , and Generation of Body Fitting Adaptive Mesh.	**L1, L2, L3**
2. Modeling of 2-D Incompressible and Invisicd Flow over Symmetrical/Cambered Aerofoil, and Plotting of Pressure distribution and Velocity vectors for Subsonic/Supersonic Mach numbers.	**L1, L2, L3,L4**
3. Modeling of 2-D Compressible and Viscid Flow over Symmetrical/Cambered Aerofoil, and Plotting of Pressure distribution and Velocity vectors for Subsonic Mach numbers.	**L1, L2, L3, L4**
4. Isentropic Flow Analysis in a 2-D Subsonic Diffuser and a Subsonic Nozzle.	**L1, L2, L3, L4**
5. Isentropic Flow Analysis in a 2-D Supersonic Diffuser and a Supersonic Nozzle.	**L1, L2, L3, L4**
6. Geometric Modeling and Mesh Generation of a 2-D Convergent-Divergent Nozzle and Analyses of flow for Adiabatic Conditions (Fanno Flow).	**L1, L2, L3, L4**
7. Geometric Modeling and Mesh Generation of a 2-D Pipe and Modeling of	**L1, L2, L3,L4**

Steady/Unsteady Heat Convection and Conduction (Rayleigh Flow).	
8. Structural Modeling of Sandwich Beam of Rectangular Cross-section and Analyses for Stress for Unsymmetrical bending case.	**L1,L2,L3,L4**
9. Structural Modeling and Stress Analysis of a Torsion Box of a Wing.	**L1,L2,L3,L4**
10. Structural Modeling and Stress Analysis of a Fuselage Frame.	**L1,L2,L3,L4**
11. Structural Modeling and Stress Analysis of a Tapered I-Section Spar.	**L1, L2, L3,L4**
12. Determine the Natural frequency and Mode shapes of a Cantilever beam under UDL.	**L1, L2, L3**
13. A Plate fixed at one end has a hole in centre and has varying thickness, Determine stresses developed due to applied static loads in vertical direction.	**L1, L2, L3**
14. A Tapered Plate fixed at one end has a hole in centre and has varying thickness, determine stresses developed due to applied static loads in vertical direction.	**L1, L2, L3**

Course outcomes: After studying the course the students will be able to

- Draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures.
- Apply different types of meshing.
- Perform the flow and stress analysis.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Team work
- Communication

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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SCHEME OF TEACHING AND EXAMINATION 2017-2018

Aeronautical Engineering
VIII SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Drawing	Duration	Theory/ Practical Marks	I.A. Marks	Total Marks	
1	17AE81	AVIONICS	4	-	3	60	40	100	4
2	17AE82	FLIGHT VEHICLE DESIGN	4	-	3	60	40	100	4
3	17AE83X	Professional Elective	3	-	3	60	40	100	3
4	17AE84	Internship / Professional Practice	Industry Oriented		3	50	50	100	2
5	17AEP85	Project Work Phase -II	-	6	3	100	100	200	6
6	17AES86	Seminar	-	4	-	-	100	100	1
TOTAL			**11**	**10**	**15**	**330**	**370**	**700**	**20**

Professional Elective	
17AE831	FLIGHT TESTING
17AE832	BOUNDARY LAYER THEORY
17AE833	OPTIMIZATION TECHNIQUES
17AE834	CRYOGENICS

1. Core subject: This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2. Professional Elective: Elective relevant to chosen specialization/ branch

3. Internship / Professional Practice: To be carried between the 6th and 7th semester vacation or 7th and 8th semester vacation period.

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AVIONICS
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII

Subject Code	**17AE81**	IA Marks	40
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the need for avionics in civil, military and space systems.
2. Appreciate the use of microprocessors, data buses and avionics system architectures.
3. Acquire the knowledge of display technologies, communication and navigation systems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Power Distribution System:** Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Need for Avionics in civil and military aircraft.	**10 Hours**	**L1, L2**
Module -2 **Inertial Navigation System:** Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing. **Electronic Flight Control System:** Fly-by-wire system: - basic concept and features. Pitch and Roll rate: - command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.	**10 Hours**	**L1, L2**
Module -3 **Electronic Flight Instrument Systems:** Display -units, presentation, failure, and annunciation. Display of air data. **Introduction to Avionics Sub Systems and Electronic Circuits:** Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.	**10 Hours**	**L1, L2, L3**
Module -4 **Principles of Digital Systems:** Digital Computers, Microprocessors, Memories **Flight Deck and Cockpits:** Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI) - Civil cockpit and military cockpit : MFDS, HUD, MFK, HOTAS.	**10 Hours**	**L1, L2**
Module -5 **Avionics Systems Integration:** Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD 1553 B.	**10 Hours**	**L1, L2**

Course Outcomes:

After studying this course, students will be able to:

1. Select the suitable data bus based on the application.
2. Identify the suitable navigation systems.
3. Distinguish the avionics system architecture.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. R.P.G. Collinson., "Introduction to Avionics Systems", Springer,3rd edition, 2011, ISBN-13: 978-9400707078
2. Ian Moir, Allan Seabridge, Aircraft Systems: Mechanics, Electrical and Avionics Subsystems Integration, Wiley, 3rd Edition, 2012.

Reference Books:

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989, ISBN-13: 978-0582018815.
2. Spitzer, C.R., "Digital Avionic Systems", McGraw-Hill Inc., US, 2nd edition, 1992, ISBN-13: 978-0070603332.
3. Mike Tooley and David Wyatt, Aircraft Communications and Navigation Systems, Butterworth Heinemann, 2007.
4. D.R. Cundy and R.S. Brown, Introduction to Avionics, Pearson, 2010.

FLIGHT VEHICLE DESIGN

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VIII

Subject Code	**17AE82**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	60

CREDITS – 04

Course Objectives: This course will enable students to

1. Comprehend the flight vehicle design process.
2. Acquire the knowledge of vehicle configuration and structural components.
3. Understand the stability & control and subsystems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Overview of Design Process:** Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation. **Thrust to Weight Ratio & Wing Loading:** Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.	**6 Hours**	**L1, L2**
Module -2 **Configuration Layout & loft**: Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Detectability. Crew station, Passenger, and Payload arrangements. **Design of Structural Components:** Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal & Vertical Tail Sizing. Tail Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.	**6 Hours**	**L1, L2**
Module -3 **Engine Selection & Flight Vehicle Performance** Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices :- Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking, Spread Sheet for Take-off and Landing. Enhanced lift design -Passive & Active. Spread Sheet	**8 Hours**	**L1, L2, L3**
Module -4 **Static Stability & Control** Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe	**10 Hours**	**L1, L2, L3**

components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Spread Sheets. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.		
Module -5 **Design Aspects of Subsystems** Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurization and Air Conditioning System, Electrical & Avionic Systems, Structural loads, Safety constraints, Material selection criteria.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Calculate the thrust to weight ratio and wing loading.
2. Compute the flight vehicle performance.
3. Select the subsystems as per vehicle design.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Daniel P. Raymer, Aircraft Design - A Conceptual Approach- AIAA Education Series, IV Edition, 2006.
2. Thomas C Corke, Design of Aircraft- Pearson Edition. Inc. © 2003.

Reference Books:

1. J Roskam, Aeroplane Design –Vol: 1 to 9
2. John Fielding, Introduction to Aircraft Design - Cambridge University Press, 2009
3. Standard Handbook for Aeronautical & Astronautical Engineers, Editor Mark Davies, Tata McGraw Hill, 2010.

Professional Elective

FLIGHT TESTING

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII
Professional Elective

Subject Code	**17AE831**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to
1. Comprehend the basic concepts of flight test instrumentation.
2. Acquire the knowledge of performance flight testing and stability control.
3. Understand the flying qualities.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Sequence, Planning and governing regulations of flight testing. Aircraft weight and center of gravity, flight testing tolerances. Method of reducing data uncertainty in flight test data - sources and magnitudes of error, avoiding and minimizing errors. **Flight test instrumentation:** Planning flight test instrumentation, Measurement of flight parameters. Onboard and ground based data acquisition system. Radio telemetry.	**6 Hours**	**L1, L2**
Module -2 **Performance flight testing - range, endurance and climb:** Airspeed – in flight calibration. Level flight performance for propeller driven aircraft and for Jet aircraft - Techniques and data reduction. Estimation of range, endurance and climb performance. **Performance flight testing -take-off, landing, turning flight:** Maneuvering performance estimation. Take-off and landing - methods, procedures and data reduction.	**6 Hours**	**L1, L2**
Module -3 **Stability and control - longitudinal and maneuvering**	**8 Hours**	**L1, L2, L3**

Static & dynamic longitudinal stability: - methods of flight testing and data reduction techniques. Stick free stability methods. Maneuvering stability methods & data reduction.		
Module -4 **Stability and control - lateral and directional** Lateral and directional static & dynamic stability: - Coupling between rolling and yawing moments. Steady heading slide slip. Definition of Roll stability. Adverse yaw effects. Aileron reversal. Regulations, test techniques and method of data reduction.	**10 Hours**	**L1, L2, L3**
Module -5 **Flying qualities:** MIL and FAR regulations. Cooper-Harper scale. Pilot Rating. Flight test procedures. **Hazardous flight testing:** Stall and spin- regulations, test and recovery techniques. Test techniques for flutter, vibration and buffeting.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Measure the flight parameters.
2. Estimate the performance of flight.
3. Apply the FAR regulations.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. Ralph D Kimberlin, Flight Testing of Fixed Wing Aircraft, AIAA educational Series,2003.
2. Benson Hamlin, Flight Testing- Conventional and Jet Propelled Airplanes, Mac Millan, 1946

Reference Books:

1. AGARD, Flight Test Manual Vol. I to IV
2. A.J. Keane, A. Sobester, Small Unmanned fixed-wing Aircraft Design, Wiley, 2017.
3. A. Filippone, Flight Performance of Fixed and Rotary Wing Aircraft, AIAA Series, 2006.

VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
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BOUNDARY LAYER THEORY

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII
Professional Elective

Subject Code	**17AE832**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the basic concepts and equations of viscous flow.
2. Acquire the knowledge of laminar boundary layer and its equations.
3. Understand the turbulence, instrumentation and measurements.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Preliminary Concepts** Some examples of viscous flow phenomena: - aerofoil, cylinder, circular pipe. Boundary conditions for viscous flow problems. The kinematics properties of viscous flow. **Fundamental Equations of Viscous Flow** Conservation of mass, momentum and energy equations. Mathematical characterisation of basic equations. Dimensionless parameters in viscous flow.	**6 Hours**	**L1, L2**
Module -2 **Solutions of Viscous Flow Equations** Classification of solutions. Couette flow, stability of Couette flow. Poiseuille steady flow through duct. Unsteady duct flow between plates with bottom injection and top suction. Plane stagnation flow-differential equation free of parameters.	**6 Hours**	**L1, L2**
Module -3 **Introduction to Laminar Boundary Layer** Laminar boundary layer equations. Flat plate Integral analysis. Displacement thickness, Momentum and Energy thicknesses for two dimensional flows; Shape factor. Some insight into boundary layer approximations. Discussion of Navier Stokes equations. Concept of thermal boundary layer.	**8 Hours**	**L1, L2, L3**

Module -4 **Laminar Boundary Layer Equations** Dimensionless variables. Laminar boundary layer equations. Similarity solutions for steady two-dimensional flow. Blasius solution for flat- plate flow, wall shear stress. Flat plate heat transfer for constant wall temperature. Some examples of Falkner-Skan potential flows. Reynolds analogy as a function of pressure gradient.	**10 Hours**	**L1, L2, L3**
Module -5 **Transition to Turbulence** Stability of laminar flows - concept of small disturbance stability. Temporal instability and Spatial instability. Stability of Blasius and Falkner-Skan profiles. Effect of wall temperature. Transition to turbulence. Affecting parameters **Incompressible Turbulent Mean Flow** Physical and mathematical description of turbulence. Fluctuations and time averaging. Turbulent flow in pipes and channels. Free turbulence: - jets, wakes and mixing layers. **Instrumentation and Measurements:** Hot wire and Hot film anemometer for turbulence measurements. Schlieren methods for flow visualization. Pressure probes, Interferometer and Smoke method.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts and equations of viscous flow.
2. Discuss the importance of Navier Stokes equation.
3. Measure the turbulence.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each

module.

Text Books:

1. H. Schlichting, `Boundary Layer Theory`, McGraw- Hill, New York, 1979.
2. Frank White,` Viscous Fluid flow` - McGraw Hill, 1991.

Reference Books:

1. J.P. Hollman and W.J. Gajda, Jr. 'Experimental methods for Engineers', 5th Edition McGraw- Hill , 1989
2. Ronald L., Panton, `Incompressible fluid flow`, John Wiley & Sons, 1984.

OPTIMIZATION TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII
Professional Elective

Subject Code	**17AE833**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course Objectives: This course will enable students to

1. Understand the unconstrained and constrained minimization.
2. Comprehend the direct search methods, discrete and dynamics programming.
3. Acquire the knowledge on finite element based optimization.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Non-linear programming. Mathematical fundamentals. Numerical evaluation of gradient. **Unconstrained Optimisation:** One dimensional, single variable optimization. Maximum of a function. Unimodal-Fibonacci method. Polynomial based methods.	**8 Hours**	**L1, L2**
Module -2 **Unconstrained Minimization:** Multivariable functions. Necessary and sufficient conditions for optimality. Convexity. Steepest Descent Method -Convergence Characteristics. Conjugate Gradient Method. Linear programming -Simplex Method.	**7 Hours**	**L1, L2**
Module -3 **Constrained Minimization:** Non-linear programming. Gradient based methods. Rosens`s gradient, Zoutendijk`s method, Generalised reduced gradient, Sequential quadratic programming. Sufficient condition for optimality.	**7 Hours**	**L1, L2, L3**
Module -4 **Direct Search Methods: D**irect search methods for nonlinear optimization. Cyclic coordinate search. Hooke and Jeeves Pattern search method. Generic algorithm. **Discrete and Dynamic Programming:** Integer and discrete programming. Branch and bound algorithm for mixed integers. General definition of dynamic programming problem. Problem modeling and computer implementation. Shortest path problem	**9 Hours**	**L1, L2**
Module -5 **Optimisation Application:** Transportation problem. Transportation simplex method. Network problems. Maximum flow in net works. General definition of dynamic programming. Problem modeling and computer implementation. **Finite Element Based Optimisation:** Parameter optimization using gradient methods -Derivative calculation. Shape optimisation. Topology	**9 Hours**	**L1, L2**

optimisation of continuum structures.

Course Outcomes:
After studying this course, students will be able to:
1. Identify the unconstrained and constrained minimization effect of fluid properties.
2. Apply the direct search methods, discrete and dynamics programming.
3. Classify the optimisation application.

Graduate Attributes:
- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
1. Ashok D Belegundu and Tirupathi R . Chandrupatla, `Optimisation Concepts and Applications in Engineering`, Pearson Education, In C.,1991.
2. Fletcher, R, `Practical Methods of Optimisation`, Wiley, New York ,2nd Edition, 2009,ISBN-13: 978-8126524259.

Reference Books:
1. Dennis J.E. and Schnabel, R. B., `Numerical Methods for Unconstrained Optimisation and Nonlinear Equations`, Prentice Hall, Engle Wood Cliffs, New Jersey, 1983.
2. S.S. Rao, ` Optimisation -Theory and Application`, Wiley Eastern Ltd., 5th Edition.1990.

CRYOGENICS

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII

Subject Code	**17AE834**	IA Marks	40
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	60

CREDITS – 03

Course objective:
This course will enable students to
1. Understand the basic of cryogenic engineering.
2. Understand the cryogenic properties and insulation.
3. Acquire the knowledge on storage of cryogenic liquids and equipments.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**

Module -1 Introduction to Cryogenic Engineering: **Thermo physical and fluid dynamic properties of liquid and gas hydrogen, Thermo physical and fluid dynamic properties of liquid and gas helium, Liquefaction systems of hydrogen and helium gases, Liquefaction systems of hydrogen and helium gases, Refrigeration and liquefaction principals; Joule Thomson effect and inversion curve; Adiabatic and isenthalpic expansion with their comparison.**	**9 Hours**	**L1, L2**
Module -2 Properties: **Cryogenic fluids, Solids at cryogenic temperatures; Superconductivity, Recuperative - Linde - Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative - Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas.** .	**8 Hours**	**L1, L2**
Module -3 Cryogenic Insulation: **Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations**	**7 Hours**	**L1, L2, L3**
Module -4 **Storage and Instrumentation of Cryogenic liquids:** Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems, Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats.	**8 Hours**	**L1, L2**
Module -5 Cryogenic Equipment: **Cryogenic heat exchangers - recuperative and regenerative; Variables affecting heat exchanger and system performance; Cryogenic compressors, Pumps, expanders; Turbo alternators; Effect of component inefficiencies; System Optimization, Magneto-caloric refrigerator; 3He-4He Dilution refrigerator; Cryopumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in Transport.**	**8 Hours**	**L1, L2**
Course Outcomes:		

After studying this course, students will be able to:

1. Recognize the basic of cryogenic engineering.
2. Identify the storage and instrumentation required for cryogenic liquids.
3. Classify the types of cryogenic equipments.

Graduate Attributes:

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

1. T.M. Flynn, Marcel Dekker., Cryogenic Engineering, CRC Press,2nd edition, 2004, ISBN-13: 978-8126504985
2. A. Bose and P. Sengupta, "Cryogenics: Applications and Progress", Tata McGraw Hill.

Reference Books:

1. J.G. Weisend II, Taylor and Francis , "Handbook of Cryogenic Engineering", CRC Press,1st edition,1998,ISBN-13: 978-1560323327
2. R.Barron,"Cryogenic Systems", Oxford University Press.
3. K.D.Timmerhaus and T.M. Flynn, "Cryogenic Process Engineering", Plenum Press,1st edition,2013,ISBN-13: 978-1468487589
4. G.G.Haselden,"Cryogenic Fundamentals", Academic Press.
5. C.A.Bailey,"Advanced Cryogenics", Springer,1971,ISBN-13: 978-0306304583
6. R.W. Vance and W.M. Duke , "Applied Cryogenic Engineering", John Wiley & sons,1962,ISBN-13: 978-0471902706