VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELAGAVI

Scheme of Teaching and Examination and Syllabus

B.E. **AERONAUTICAL ENGINEERING**

III-VIIISEMESTER

(Effective from Academic year 2018-19)

B. E. AERONATICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

TRANSFORM CALCULUS, FOURIER SERIES AND NUMERICAL TECHNIQUES
(Common to all Programmes)

Course Code	**18MAT31**	CIE Marks	40
Teaching Hours/Week (L: T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To have an insight into Fourier series, Fourier transforms, Laplace transforms, Difference equations and Z-transforms.
- To develop the proficiency in variational calculus and solving ODE's arising in engineering applications, using numerical methods.

Module-1

Laplace Transform: Definition and Laplace transforms of elementary functions (statements only). Laplace transforms of Periodic functions (statement only) and unit-step function – problems.
Inverse Laplace Transform: Definition and problems, Convolution theorem to find the inverse Laplace transforms (without Proof) and problems. Solution of linear differential equations using Laplace transforms.

Module-2

Fourier Series: Periodic functions, Dirichlet's condition. Fourier series of periodic functions period 2π and arbitrary period. Half range Fourier series. Practical harmonic analysis.

Module-3

Fourier Transforms: Infinite Fourier transforms, Fourier sine and cosine transforms. Inverse Fourier transforms. Problems.
Difference Equations and Z-Transforms: Difference equations, basic definition, z-transform-definition, Standard z-transforms, Damping and shifting rules, initial value and final value theorems (without proof) and problems, Inverse z-transform and applications to solve difference equations.

Module-4

Numerical Solutions of Ordinary Differential Equations(ODE's):
Numerical solution of ODE's of first order and first degree- Taylor's series method, Modified Euler's method. Runge -Kutta method of fourth order, Milne's and Adam-Bash forth predictor and corrector method (No derivations of formulae)-Problems.

Module-5

Numerical Solution of Second Order ODE's: Runge-Kutta method and Milne's predictor and corrector method. (No derivations of formulae).
Calculus of Variations: Variation of function and functional, variational problems, Euler's equation, Geodesics, hanging chain, problems.

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

- CO1: Use Laplace transform and inverse Laplace transform in solving differential/ integral equation arising in network analysis, control systems and other fields of engineering.
- CO2: Demonstrate Fourier series to study the behaviour of periodic functions and their applications in system communications, digital signal processing and field theory.
- CO3: Make use of Fourier transform and Z-transform to illustrate discrete/continuous function arising in wave and heat propagation, signals and systems.
- CO4: Solve first and second order ordinary differential equations arising in engineering problems using single step and multistep numerical methods.
- CO5:Determine the externals of functionals using calculus of variations and solve problems arising in dynamics of rigid bodies and vibrational analysis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.

- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2016
2	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition, 2016
Reference Books				
1	Advanced Engineering Mathematics	C. Ray Wylie, Louis C. Barrett	McGraw-Hill Book Co	6th Edition, 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B.V. Ramana	McGraw-Hill	11th Edition,2010
4	A Textbook of Engineering Mathematics	N.P.Bali and Manish Goyal	Laxmi Publications	6th Edition, 2014
5	Advanced Engineering Mathematics	Chandrika Prasad and Reena Garg	Khanna Publishing,	2018

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B. E. AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Aero Thermodynamics

Course Code	**18AS32/18AE32**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

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; definition, units and sign convention. Problems.

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.

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.

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
Maxwell's equations, Tds relations, ratio of heat capacities, evaluation of thermodynamic properties from an equation of state.

Module-5

Gas Power Cycles: Efficiency of air standard cycles, Carnot, Otto, Diesel cycles, P-V & T-S diagram, calculation of efficiency.

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.

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

- CO1: Apply the concepts and definitions of thermodynamics.
- CO2: Differentiate thermodynamic work and heat and apply I law and II law of thermodynamics to different process.
- CO3: Apply the principles of various gas cycles.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
		Textbooks		
1	Basic and Applied Thermodynamics	P K Nag	Tata McGraw Hill	2nd Ed , 2002
2.	Basic Engineering Thermodynamics	A Venkatesh	Universities Press, India	2007
		Reference Books		
1	Thermodynamics: An Engineering Approach	Yunus A. Cenegal and Michael A. Boles	Tata McGraw Hill	2002
2	Engineering Thermodynamics	J.B. Jones and G.A. Hawkins, John Wiley and Sons	Wiley	1986
3	Fundamentals of Classical Thermodynamics	G. J. Van Wylen and R.E. Sonntag	Wiley Eastern, Wiley	1985
4	An Introduction to Thermodynamics	Y.V.C. Rao	Wiley Eastern	1993
5	Basic Thermodynamics	B. K Venkanna, Swati B. Wadavadagi	PHI, New Delhi	2010

B. E. AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Mechanics of Materials

Course Code	**18AS33/18AE33**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic concepts of strength of materials.
- Acquire the knowledge of stress, strain under different loadings.
- Understand the properties of materials.

Module-1

Basics of linear elasticity: The concept of stress& strain, state of stress & Strain at a point, Equilibrium equations, The state of plane stress and plane strain. Compatibility equations, Constitutive Laws (Hooke's Law), Stress-strain curves for brittle and ductile materials, Allowable stress, Material selection for structural performance.

Simple & Compound Stresses: Extension / Shortening of a bar, bars with cross sections varying in steps, bars with continuously varying cross sections. Elongation due to self-weight. Volumetric strain, expression for volumetric strain, elastic constants, simple shear stress, shear strain, temperature stresses, Introduction to Plane stress, stresses on inclined sections, principal stresses & strains, Analytical & graphical method (Mohr's Circle) to find principal stresses & strains.

Module-2

Bending Moment and Shear Force in Beams: Introduction, Types of beams, loads and reactions, shear forces and bending moments, rate of loading, sign conventions, relationship between shear force and bending moments. Shear force and bending moment diagrams for different beams subjected to concentrated loads, uniformly distributed load, (UDL) uniformly varying load (UVL) and couple for different types of beams.

Euler-Bernoulli beam theory: The Euler-Bernoulli assumptions, Implications of the Euler-Bernoulli assumptions, the Euler-Bernoulli Beam theory derivation, Bending stress equation, Moment carrying capacity of a section. Shearing stresses in beams, shear stress across rectangular, circular, symmetrical I and T sections (Only Numerical).

Module-3

Deflection of Beams: Introduction, Differential equation for deflection. Equations for deflection, slope and bending moment. Double integration method for cantilever and simply supported beams for point load, UDL, UVL and Couple. Macaulay's method.

Torsion of Circular Shafts and Elastic Stability of Columns: Introduction. Pure torsion, assumptions, derivation of torsional equations, polar modulus, torsional rigidity / stiffness of shafts. Power transmitted by solid and hollow circular shafts.

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 virtual work applied to beams. 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.

Module-5

Mechanical Properties of materials:

Fracture: Type I, Type II and Type III.

Creep: Description of the phenomenon with examples. Three stages of creep, creep properties, stress relaxation.

Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, fatigue testing and S-N diagram.

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

- CO1: Apply the basic concepts of strength of materials.
- CO2: Compute stress, strain under different loadings.
- CO3: Distinguish the properties of different materials.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Strength of Materials	S. S. Bhavaikatii	Vikas Publications House, New Delhi	2012
2	Strength of Materials	S. Ramamrutham	Dhanapath Rai Publishing Company	2012
Reference Books				
1	Introduction to Aircraft Structural Analysis	T. H. G Megson	Butterworth-Heinemann	2007
2	Mechanics of Materials	Beer. F. P. and Johnston. R	McGraw Hill Publishers	2006
3	Elements of Strength of Materials	Timoshenko and Young	East-West Press	1976
4	Structural Analysis	O. A. Bauchau and J. I. Craig	Springer Dordrecht Heidelberg London New York	

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Elements of Aeronautics

Course Code	**18AE34**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

Module-1

Introduction to Aircrafts
History of aviation; Atmosphere and its properties; Classification of aircrafts; Basic components of an aircraft; aircraft axis system; aircraft motions; control surfaces and high lift devices; conventional design configurations; principle of operation of each major part; Helicopters, their parts and functions.

Aircraft Structures and Materials:
Introduction; structural members;general types of construction; monocoque, semi-monocoque and geodesic structures; typical wing and fuselage structure; metallic and non-metallic materials for aircraft application.

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.

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.

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 slats 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.

Module-5

Introduction to Aircraft Systems:
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.

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

1. CO1 :Appreciate and apply the basic principle of aviation
2. CO2 :Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft propulsion and aircraft materials during the development of an aircraft
3. CO3: Comprehend the complexities involved during development of flight vehicles.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Flight	John D. Anderson	McGraw-Hill Education	2011
2	Fundamentals of Flight Vol-I to Vol-IV	Lalit Gupta and O P Sharma	Himalayan Books	2006
Reference Books				
1	Flight without formulae	A.C. Kermode	Pearson Education India	1989
2	Flight stability and automatic control	Nelson R.C	McGraw-Hill International Editions	1998
3	Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration	Ian Moir, Allan Seabridge	John Wiley & Sons	2011

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Mechanics of Fluids

Course Code	**18AS35/18AE35**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic fluid properties.
- Understand the governing laws of fluid flow.
- Acquire the knowledge of types of fluid flows.

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.

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).

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.

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.

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.

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

- CO1: Evaluate the effect of fluid properties.
- CO2: Apply the governing laws of fluid flow.
- CO3: Classify different types of fluid flows.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fluid Mechanics and Hydraulics Machines	Bansal, R.K	Laxmi Publications (P) Ltd., New Delhi	2015
2	Fluid Mechanics	Rathakrishnan. E	Prentice-Hall of India Pvt. Ltd	2010
Reference Books				
1	Fluid Mechanics and Applications	Yunus A. Cengel & John M Cimbala	McGraw Hill Education;	3rd edition,2013
2	Hydraulic Fluid Mechanics and Fluid Machines	Ramamritham. S	Dhanpat Rai& Sons, Delhi	1988
3	Engineering Fluid Mechanics	Kumar. K.L	Eurasia Publishing House (P) Ltd., New Delhi	VII Ed.,1995
4	Fluid Mechanics	Streeter. V. L., and Wylie, E.B	McGraw Hill	1983

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

Measurement and Metrology

Course Code	**18AE36**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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 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.

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

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

1. CO1: Apply the standards of measurement, system of limits, fits, tolerances and gauging.
2. CO2: Identify and use appropriate measuring instruments.
3. CO3 : Acquire the knowledge on measurement and measurement systems

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Mechanical Measurements	Beckwith Marangoni and Lienhard, John H. Lienhard V	6th Ed.,	2006
2	Engineering Metrology	R.K.Jain	Khanna Publishers	1994
Reference Books				
1	Engineering Metrology	I.C.Gupta	Dhanpat Rai Publications	2013
2	Industrial Instrumentation	Alsutko, Jerry. D.Faulk	Thompson Asia Pvt. Ltd	2002

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MEASUREMENTS AND METROLOGY LAB

Course Code	**18AEL37A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Learn the concepts of mechanical measurements and metrology
- Use the concept of accuracy, error and calibration
- Use the basic metrological instruments

Sl. No.	Experiments
1	Calibration of Pressure Gauge
2	Calibration of Thermocouple
3	Calibration of LVDT
4	Calibration of Load cell
5	Determination of modulus of elasticity of a mild steel specimen using strain gauges.
6	Comparison and measurements using vernier caliper and micrometer
7	Measurement of vibration parameters using vibration setup.
8	Measurements using Optical Projector / Toolmaker Microscope.
9	Measurement of angle using Sine Center / Sine bar / bevel protractor
10	Measurement of alignment using Autocollimator / Roller set
11	Measurement of Screw thread Parameters using Two-wire or Three-wire method.
12	Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
13	Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer
14	Calibration of Micrometer using slip gauges.

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

1. CO1: Identify and classify different measuring tools related to experiments.
2. CO2: Identify, define, and explain accuracy, precision, and some additional terminology.
3. CO3: 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MATERIAL TESTING LAB

Course Code	**18AEL37B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Hardness Testing – Vicker's, Brinell, Rockwell
2	Tensile Test
3	Flexural Test
4	Torsional Test
5	Impact Test
6	Shear Test
7	Fatigue Test
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
9	Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-treated samples.
10	To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.
11	Visual Testing Technique, Dye penetration testing. To study the defects of Cast and Welded specimens.
12	Magnetic Particle Inspection.
13	Ultrasonic Inspection.
14	Eddy Current Inspection

Course outcomes:

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

- Apply the relations among materials and their properties.
- Differentiate the formation, properties and significance of the alloys through different experiments.
- 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - III

MACHINE SHOP LAB

Course Code	**18AEL38**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Introduction to Machining operations & tools (Lathe machine.)
2	Introduction to Machining operations & tools (Shaper machine)
3	Machining of plain turning and facing
4	Machining of taper turning & step turning
5	Machining of knurling operation
6	Machining of drilling operation
7	Machining of boring operation
8	Machining of internal thread cutting
9	Machining of external thread cutting
10	Machining of eccentric turning
11	Machining of hexagon in shaping machine
12	Machining of square in shaping machine
13	Cutting of gear teeth using milling machine
14	Grinding operations using grinding machine.

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

1. CO1: Demonstrate the operation of general purpose machine tools and manufacturing process.
2. CO2 :Identify the special purpose machine tools for specific requirements
3. CO3: Develop physical models using different manufacturing processes.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B. E. (Common to all Programmes)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER –II / III / IV

Aadalitha Kannada

Course Code	**18KAK28/39/49**	CIE Marks	100
Teaching Hours/Week (L:T:P)	(0:2:0)		
Credits	01		

ಆಡಳಿತ ಕನ್ನಡ ಕಲಿಕೆಯ ಉದ್ದೇಶಗಳು:

- ಪದವಿ ವಿದ್ಯಾರ್ಥಿಳಾಗಿರುವುದರಿಂದ ಆಡಳಿತ ಕನ್ನಡದ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.
- ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕನ್ನಡ ಭಾಷೆಯ ವ್ಯಾಕರಣದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾ ರಚನೆಯಲ್ಲಿನ ನಿಯಮಗಳನ್ನು ಪರಿಚಯಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾ ಬರಹದಲ್ಲಿ ಕಂಡುಬರುವ ದೋಷಗಳು ಹಾಗೂ ಅವುಗಳ ನಿವಾರಣೆ. ಮತ್ತು ಲೇಖನ ಚಿಹ್ನೆಗಳನ್ನು ಪರಿಚಯಿಸುವುದು.
- ಸಾಮಾನ್ಯ ಅರ್ಜಿಗಳು, ಸರ್ಕಾರಿ ಮತ್ತು ಅರೆ ಸರ್ಕಾರಿ ಪತ್ರವ್ಯವಹಾರದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡಿಸುವುದು.
- ಭಾಷಾಂತರ ಮತ್ತು ಪ್ರಬಂಧ ರಚನೆ ಬಗ್ಗೆ ಅಸಕ್ತಿ ಮೂಡಿಸುವುದು.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ ಮತ್ತು ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳ ಪರಿಚಯ ಮಾಡಿಕೊಡುವುದು.

ಪರಿವಿಡಿ (ಪಠ್ಯಪುಸ್ತಕದಲ್ಲಿರುವ ವಿಷಯಗಳ ಪಟ್ಟಿ)

ಅಧ್ಯಾಯ – 1 ಕನ್ನಡಭಾಷೆ – ಸಂಕ್ಷಿಪ್ತ ವಿವರಣೆ.
ಅಧ್ಯಾಯ – 2 ಭಾಷಾ ಪ್ರಯೋಗದಲ್ಲಾಗುವ ಲೋಪದೋಷಗಳು ಮತ್ತು ಅವುಗಳ ನಿವಾರಣೆ.
ಅಧ್ಯಾಯ – 3 ಲೇಖನ ಚಿಹ್ನೆಗಳು ಮತ್ತು ಅವುಗಳ ಉಪಯೋಗ.
ಅಧ್ಯಾಯ – 4 ಪತ್ರ ವ್ಯವಹಾರ.
ಅಧ್ಯಾಯ – 5 ಆಡಳಿತ ಪತ್ರಗಳು.
ಅಧ್ಯಾಯ – 6 ಸರ್ಕಾರದ ಆದೇಶ ಪತ್ರಗಳು.
ಅಧ್ಯಾಯ – 7 ಸಂಕ್ಷಿಪ್ತ ಪ್ರಬಂಧ ರಚನೆ (ಪ್ರಿಸೈಸ್ ರೈಟಿಂಗ್), ಪ್ರಬಂಧ ಮತ್ತು ಭಾಷಾಂತರ.
ಅಧ್ಯಾಯ – 8 ಕನ್ನಡ ಶಬ್ದಸಂಗ್ರಹ.
ಅಧ್ಯಾಯ – 9 ಕಂಪ್ಯೂಟರ್ ಹಾಗೂ ಮಾಹಿತಿ ತಂತ್ರಜ್ಞಾನ.
ಅಧ್ಯಾಯ – 10 ಪಾರಿಭಾಷಿಕ ಆಡಳಿತ ಕನ್ನಡ ಪದಗಳು ಮತ್ತು ತಾಂತ್ರಿಕ/ ಕಂಪ್ಯೂಟರ್ ಪಾರಿಭಾಷಿಕ ಪದಗಳು.

ಆಡಳಿತ ಕನ್ನಡ ಕಲಿಕೆಯ ಫಲಿತಾಂಶಗಳು:

- ಆಡಳಿತ ಭಾಷೆ ಕನ್ನಡದ ಪರಿಚಯವಾಗುತ್ತದೆ.
- ವಿದ್ಯಾರ್ಥಿಗಳಲ್ಲಿ ಕನ್ನಡ ಭಾಷೆಯ ವ್ಯಾಕರಣದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡುತ್ತದೆ.
- ಕನ್ನಡ ಭಾಷಾ ರಚನೆಯಲ್ಲಿನ ನಿಯಮಗಳು ಮತ್ತು ಲೇಖನ ಚಿಹ್ನೆಗಳು ಪರಿಚಯಿಸಲ್ಪಡುತ್ತವೆ.
- ಸಾಮಾನ್ಯ ಅರ್ಜಿಗಳು, ಸರ್ಕಾರಿ ಮತ್ತು ಅರೆ ಸರ್ಕಾರಿ ಪತ್ರವ್ಯವಹಾರದ ಬಗ್ಗೆ ಅರಿವು ಮೂಡುತ್ತದೆ.
- ಭಾಷಾಂತರ ಮತ್ತು ಪ್ರಬಂಧ ರಚನೆ ಬಗ್ಗೆ ಅಸಕ್ತಿ ಮೂಡುತ್ತದೆ.
- ಕನ್ನಡ ಭಾಷಾಭ್ಯಾಸ ಮತ್ತು ಸಾಮಾನ್ಯ ಕನ್ನಡ ಹಾಗೂ ಆಡಳಿತ ಕನ್ನಡದ ಪದಗಳು ಪರಿಚಯಿಸಲ್ಪಡುತ್ತವೆ.

ಪರೀಕ್ಷೆಯ ವಿಧಾನ : ನಿರಂತರ ಆಂತರಿಕ ಮೌಲ್ಯಮಾಪನ – ಅಖಇ **(ಅಟಿಣಟಿಣಾ ಖಟಿಣಜಿಟಿಚಿಟ ಇತಿಚಿಟಣಚಿಣಟಿ):**
ಕಾಲೇಜು ಮಟ್ಟದಲ್ಲಿಯೆ ಆಂತರಿಕ ಪರೀಕ್ಷೆಯನ್ನು 100 ಅಂಕಗಳಿಗೆ ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು ನಿರ್ದೇಶನದಂತೆ ನಡೆಸತಕ್ಕದ್ದು.

ಪಠ್ಯಪುಸ್ತಕ : ಆಡಳಿತ ಕನ್ನಡ ಪಠ್ಯ ಪುಸ್ತಕ (ಏಚಿಟಿಟಿಚಿಜಚಿ ಜಿಊ ಂಜಟುಟ್ಡಿಚಿಣಟಿ)

ಸಂಪಾದಕರು

ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ

ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ

ಪ್ರಕಟಣೆ : ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

B. E. (Common to all Programmes)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER –II & III/IV

Vyavaharika Kannada

Course Code	**18KVK28/39/49**	CIE Marks	100
Teaching Hours/Week (L:T:P)	(0:2:0)		
Credits	01		

Course Learning Objectives:

The course will enable the students to understand Kannada and communicate in Kannada language.

Table of Contents:

Course Outcomes:

At the end of the course, the student will be able to understand Kannada and communicate in Kannada language.

ಪರೀಕ್ಷೆಯ ವಿಧಾನ : ನಿರಂತರ ಆಂತರಿಕ ಮೌಲ್ಯಮಾಪನ – ಅಭಇ (ಅಡಟಿಣಟಿಣಾ ಖಟಿಣಜಡಿಟಿಚಿಟ ಇತಚಿಟಣಚಿಣಚಟಿ):

ಕಾಲೇಜು ಮಟ್ಟದಲ್ಲಿಯೆ ಆಂತರಿಕ ಪರೀಕ್ಷೆಯನ್ನು 100 ಅಂಕಗಳಿಗೆ ವಿಶ್ವವಿದ್ಯಾಲಯದ ನಿಯಮಗಳು ಮತ್ತು ನಿರ್ದೇಶನದಂತೆ ನಡೆಸತಕ್ಕದ್ದು.

ಖಿಷಣಛಜಇ (ಪಠ್ಯಪುಸ್ತಕ): ವ್ಯಾವಹಾರಿಕ ಕನ್ನಡ ಪಠ್ಯ ಪುಸ್ತಕ (ಗಿಥಿಚಿತಚಿಟಿಚಿಡಿಜಣಚಿ ಏಚಿಟಿಟಿಚಿಜಚಿ ಖಿಷಣಾ ಃಛಜಇ)

ಸಂಪಾದಕರು

ಡಾ. ಎಲ್. ತಿಮ್ಮೇಶ

ಪ್ರೊ. ವಿ. ಕೇಶವಮೂರ್ತಿ

ಪ್ರಕಟಣೆ : ಪ್ರಸಾರಾಂಗ, ವಿಶ್ವೇಶ್ವರಯ್ಯ ತಾಂತ್ರಿಕ ವಿಶ್ವವಿದ್ಯಾಲಯ, ಬೆಳಗಾವಿ.

B. E. (Common to all Programmes)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - III

CONSTITUTION OF INDIA, PROFESSIONAL ETHICS AND CYBER LAW (CPC)

Course Code	**18CPC39/49**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Course Learning Objectives: To

- know the fundamental political codes, structure, procedures, powers, and duties of Indian government institutions, fundamental rights, directive principles, and the duties of citizens
- Understand engineering ethics and their responsibilities; identify their individual roles and ethical responsibilities towards society.
- Know about the cybercrimes and cyber laws for cyber safety measures.

Module-1

Introduction to Indian Constitution:
The Necessity of the Constitution, The Societies before and after the Constitution adoption. Introduction to the Indian constitution, The Making of the Constitution, The Role of the Constituent Assembly - Preamble and Salient features of the Constitution of India. Fundamental Rights and its Restriction and limitations in different Complex Situations. Directive Principles of State Policy (DPSP) and its present relevance in our society with examples. Fundamental Duties and its Scope and significance in Nation building.

Module-2

Union Executive and State Executive:
Parliamentary System, Federal System, Centre-State Relations. Union Executive – President, Prime Minister, Union Cabinet, Parliament - LS and RS, Parliamentary Committees, Important Parliamentary Terminologies. Supreme Court of India, Judicial Reviews and Judicial Activism. State Executives – Governor, Chief Minister, State Cabinet, State Legislature, High Court and Subordinate Courts, Special Provisions (Articles 370.371,371J) for some States.

Module-3

Elections, Amendments and Emergency Provisions:
Elections, Electoral Process, and Election Commission of India, Election Laws. Amendments - Methods in Constitutional Amendments (How and Why) and Important Constitutional Amendments. Amendments – 7,9,10,12,42,44, 61, 73,74, ,75, 86, and 91,94,95,100,101,118 and some important Case Studies. Emergency Provisions, types of Emergencies and its consequences.

Constitutional special provisions:
Special Provisions for SC and ST, OBC, Women, Children and Backward Classes.

Module-4

Professional / Engineering Ethics:
Scope & Aims of Engineering & Professional Ethics - Business Ethics, Corporate Ethics, Personal Ethics. Engineering and Professionalism, Positive and Negative Faces of Engineering Ethics, Code of Ethics as defined in the website of Institution of Engineers (India): Profession, Professionalism, and Professional Responsibility. Clash of Ethics, Conflicts of Interest. Responsibilities in Engineering Responsibilities in Engineering and Engineering Standards, the impediments to Responsibility. Trust and Reliability in Engineering, IPRs (Intellectual Property Rights), Risks, Safety and liability in Engineering

Module-5

Internet Laws, Cyber Crimes and Cyber Laws:
Internet and Need for Cyber Laws, Modes of Regulation of Internet, Types of cyber terror capability, Net neutrality, Types of Cyber Crimes, India and cyber law, Cyber Crimes and the information Technology Act 2000, Internet Censorship. Cybercrimes and enforcement agencies.

Course Outcomes: On completion of this course, students will be able to,

CO 1: Have constitutional knowledge and legal literacy.
CO 2: Understand Engineering and Professional ethics and responsibilities of Engineers.
CO 3: Understand the the cybercrimes and cyber laws for cyber safety measures.

Question paper pattern for SEE and CIE:

- The SEE question paper will be set for 100 marks and the marks scored by the students will proportionately be reduced to 60. The pattern of the question paper will be objective type (MCQ).
- For the award of 40 CIE marks, refer the University regulations 2018.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Constitution of India, Professional Ethics and Human Rights	Shubham Singles, Charles E. Haries, and et al	Cengage Learning India	2018
2	Cyber Security and Cyber Laws	Alfred Basta and et al	Cengage Learning India	2018
Reference Books				
3	Introduction to the Constitution of India	Durga Das Basu	Prentice –Hall,	2008.
4	Engineering Ethics	M. Govindarajan, S. Natarajan, V. S. Senthilkumar	Prentice –Hall,	2004

B.E.(Common to all Programmes)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - III

ADDITIONAL MATHEMATICS – I
(Mandatory Learning Course: Common to All Programmes)
(A Bridge course for Lateral Entry students under Diploma quota to BE/B. Tech. programmes)

Course Code	**18MATDIP31**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	**0**	Exam Hours	03

Course Learning Objectives:

- To provide basic concepts of complex trigonometry, vector algebra, differential and integral calculus.
- To provide an insight into vector differentiation and first order ODE's.

Module-1

Complex Trigonometry: Complex Numbers: Definitions and properties. Modulus and amplitude of a complex number, Argand's diagram, De-Moivre's theorem (without proof).
Vector Algebra: Scalar and vectors. Addition and subtraction and multiplication of vectors- Dot and Cross products, problems.

Module-2

Differential Calculus: Review of successive differentiation-illustrative examples. Maclaurin's series expansions-Illustrative examples. Partial Differentiation: Euler's theorem-problems on first order derivatives only. Total derivatives-differentiation of composite functions. Jacobians of order two-Problems.

Module-3

Vector Differentiation: Differentiation of vector functions. Velocity and acceleration of a particle moving on a space curve. Scalar and vector point functions. Gradient, Divergence, Curl-simple problems. Solenoidal and irrotational vector fields-Problems.

Module-4

Integral Calculus: Review of elementary integral calculus. Reduction formulae for $\sin^n x$, $\cos^n x$ (with proof) and $\sin^m x \cos^n x$ (without proof) and evaluation of these with standard limits-Examples. Double and triple integrals-Simple examples.

Module-5

Ordinary differential equations (ODE's. Introduction-solutions of first order and first-degree differential equations: exact, linear differential equations. Equations reducible to exact and Bernoulli's equation.

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

- CO1: Apply concepts of complex numbers and vector algebra to analyze the problems arising in related area.
- CO2: Use derivatives and partial derivatives to calculate rate of change of multivariate functions.
- CO3: Analyze position, velocity and acceleration in two and three dimensions of vector valued functions.
- CO4: Learn techniques of integration including the evaluation of double and triple integrals.
- CO5: Identify and solve first order ordinary differential equations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	43rd Edition, 2015
Reference Books				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2015
2	Engineering Mathematics	N. P .Bali and Manish Goyal	Laxmi Publishers	7th Edition, 2007
3	Engineering Mathematics Vol. I	Rohit Khurana	Cengage Learning	1st Edition, 2015

B. E. AEROSPACE ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

COMPLEX ANALYSIS, PROBABILITY AND STATISTICAL METHODS
(Common to all programmes)
[As per Choice Based Credit System (CBCS) scheme]

Course Code	**18MAT41**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:2:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- To provide an insight into applications of complex variables, conformal mapping and special functions arising in potential theory, quantum mechanics, heat conduction and field theory.
- To develop probability distribution of discrete, continuous random variables and joint probability distribution occurring in digital signal processing, design engineering and microwave engineering.

Module-1

Calculus of complex functions: Review of function of a complex variable, limits, continuity, and differentiability. Analytic functions: Cauchy-Riemann equations in Cartesian and polar forms and consequences.
Construction of analytic functions: Milne-Thomson method-Problems.

Module-2

Conformal transformations: Introduction. Discussion of transformations:$w = Z^2, w = e^z, w = z + \frac{1}{z}, (z \neq 0)$.Bilinear transformations- Problems.
Complex integration: Line integral of a complex function-Cauchy's theorem and Cauchy's integral formula and problems.

Module-3

Probability Distributions: Review of basic probability theory. Random variables (discrete and continuous), probability mass/density functions. Binomial, Poisson, exponential and normal distributions- problems (No derivation for mean and standard deviation)-Illustrative examples.

Module-4

Statistical Methods: Correlation and regression-Karl Pearson's coefficient of correlation and rank correlation -problems. Regression analysis- lines of regression –problems.
Curve Fitting: Curve fitting by the method of least squares- fitting the curves of the form-
$y = ax + b, y = ax^b and y = ax^2 + bx + c$.

Module-5

Joint probability distribution: Joint Probability distribution for two discrete random variables, expectation and covariance.
Sampling Theory: Introduction to sampling distributions, standard error, Type-I and Type-II errors. Test of hypothesis for means, student's t-distribution, Chi-square distribution as a test of goodness of fit.

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

- Use the concepts of analytic function and complex potentials to solve the problems arising in electromagnetic field theory.
- Utilize conformal transformation and complex integral arising in aerofoil theory, fluid flow visualization and image processing.
- Apply discrete and continuous probability distributions in analyzing the probability models arising in engineering field.
- Make use of the correlation and regression analysis to fit a suitable mathematical model for the statistical data.
- Construct joint probability distributions and demonstrate the validity of testing the hypothesis.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition,2016
2	Higher Engineering Mathematics	B. S. Grewal	Khanna Publishers	44th Edition, 2017
3	Engineering Mathematics	Srimanta Pal et al	Oxford University Press	3rd Edition,2016
Reference Books				
1	Advanced Engineering Mathematics	C. Ray Wylie, Louis C.Barrett	McGraw-Hill	6th Edition 1995
2	Introductory Methods of Numerical Analysis	S.S.Sastry	Prentice Hall of India	4th Edition 2010
3	Higher Engineering Mathematics	B. V. Ramana	McGraw-Hill	11th Edition,2010
4	A Text Book of Engineering Mathematics	N. P. Bali and Manish Goyal	Laxmi Publications	2014
5	Advanced Engineering Mathematics	Chandrika Prasad and Reena Garg	Khanna Publishing,	2018

Web links and Video Lectures:

1. http://nptel.ac.in/courses.php?disciplineID=111
2. http://www.class-central.com/subject/math(MOOCs)
3. http://academicearth.org/
4. VTU EDUSAT PROGRAMME - 20

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Aerodynamics-I

Course Code	**18AE42/18AS42**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:1:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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. Numericals.

Module-4

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.

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.

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

1. CO1 :Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
2. CO2 :Compute and analyse the incompressible flow over finite wings
3. CO3 : Apply finite wing theory and design high lift systems from the aerodynamics view point

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fundamental of Aerodynamics	Anderson J.D	McGraw-Hill International Edition, New York	5th edition,2011
2	Aerodynamics for Engineering Students	E. L. Houghton, P.W. Carpenter	Elsevier, New York	5th edition,2010
Reference Books				
3	Aerodynamics	Clancy L. J.	Sterling book house, New Delhi	2006
4	Theoretical Aerodynamics	Louis M. Milne-Thomson	Dover Publications, USA	Imported Edition,2011

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Aircraft Propulsion

Course Code	**18AE43**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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.

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

1. CO1: Apply the basic principle and theory of aircraft propulsion.
2. CO2 : Explain the functions of centrifugal, axial compressors, axial and radial turbines
3. CO3: Analyse the performance of nozzles & inlets and combustion chamber.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft propulsion	Bhaskar Roy	Elsevier	2011
2	Gas Turbines	V. Ganesan	Tata McGraw-Hill	2010
Reference Books				
1	Mechanics & Thermodynamics of Propulsion	Hill, P.G. & Peterson, C.R	Addison – Wesley Longman INC,	1999
2	Gas Turbine Theory	Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H	Longman	1989
3	Gas Turbine Engine Technology	Irwin E. Treager	Tata McGraw Hill Publishing Co. Ltd.	7th Edition,2003
4	Fundamentals of Compressible Flow with Aircraft and Rocket propulsion	S. M. Yahya	New Age International Publications, New Delhi	4th Edition,2014
5	Aerodynamics	Clancy L. J.	Sterling book house, New Delhi	2006

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Mechanisms and Machine Theory

Course Code	**18AE44/18AS44**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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 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

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

1. CO1: Apply the theory of velocity, acceleration and static force analysis to design of mechanisms.
2. CO2: Design spur gears, gear train, balancing of rotating and reciprocating masses.
3. CO3 : Apply governors and gyroscope

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Machines	**Rattan S.S**	Tata McGraw-Hill Publishing Company Ltd., New Delhi	3rd edition -2009
2	Theory of Machines & Mechanisms	**J.J. Uicker, G.R. Pennock, J.E. Shigley**	OXFORD	3rd Ed. 2009
Reference Books				
1	Theory of Machines	**R. S. Khurmi, J.K. Gupta**	Eurasia Publishing House	2008
2	Design of Machinery	**Robert L Norton**	McGraw Hill	2001
3	Mechanism and Machine theory	Ambekar	PHI Learning Pvt. Ltd	2007

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Aircraft Material Science

Course Code	**18AE45**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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;

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.

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.

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 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.

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

1. CO1: Identify appropriate aircraft materials for a given application.
2. CO2: Explain the properties of super alloys, ablative materials and high energy material.
3. CO3: Understand material corrosion process and apply prevention technique.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft Material and Processes	**Titterton G F**	English Book Store, New Delhi	1998
2	Advanced Aerospace Material	**H Buhl**	Spring Berlin	1992
Reference Books				
1	Handbook of Aircraft materials	**C G Krishnadas**	Interline publishers, Bangalore	1993
2	Aerospace material	**Balram Gupta, S**	Vol. 1,2,3 ARDB, Chand & Co	1996
3	Materials for Missiles and Space	**Parker E R**	John Wiley, McGraw-Hill	1963
4	Materials of Aircraft Construction	**Hill E T**	Pitman London	

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

Turbomachines

Course Code	**18AE46**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

Module-5

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

1. CO1: Compute the energy transfer and energy transformation in turbomachines.
2. CO2: Analyze the design of turbomachine blades.
3. CO3 : Apply hydraulic pumps and turbines for specific requirements

Question paper pattern:

- The question paper will have ten full questions carrying equal marks. Each full question consisting of 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Turbines, Compressors & Fans	S.M. Yahya	Tata-McGraw Hill Co	2nd Edition (2002)
2	Principles of Turbo Machinery	D.G. Shephered	The Macmillan Company	1964
Reference Books				
1	An introduction to Energy conversion, Volume III, Turbo machinery	V.Kadambi and Manohar Prasad	Wiley Eastern Ltd	1977
2	Turbomachines	Govinde Gowda and Nagaraj	MM Publishers	9th Edition,2016
3	Fundamentals of Turbomachinery	B.K.Venkanna	Prentice Hall India	2009

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – IV

MATERIAL TESTING LAB

Course Code	**18AEL47A**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Hardness Testing – Vicker's, Brinell, Rockwell
2	Tensile Test
3	Flexural Test
4	Tensional Test
5	Impact Test
6	Shear Test
7	Fatigue Test
8	Preparation of specimen for metallographic examination of different engineering materials. Identification
9	Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-
10	To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.
11	Visual Testing Technique, Dye penetration testing. To study the defects of Cast and Welded specimens.
12	Magnetic Particle Inspection.
13	Ultrasonic Inspection.
14	Eddy Current Inspection

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

- Apply the relations among materials and their properties.
- Differentiate the formation, properties and significance of the alloys through different experiments.
- 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

MEASUREMENTS AND METROLOGY LAB

Course Code	**18AEL47B**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- Learn the concepts of mechanical measurements and metrology
- Use the concept of accuracy, error and calibration
- Use the basic metrological instruments

Sl. No.	Experiments
1	Calibration of Pressure Gauge
2	Calibration of Thermocouple
3	Calibration of LVDT
4	Calibration of Load cell
5	Determination of modulus of elasticity of a mild steel specimen using strain gauges.
6	Comparison and measurements using vernier caliper and micrometer
7	Measurement of vibration parameters using vibration setup.
8	Measurements using Optical Projector / Toolmaker Microscope.
9	Measurement of angle using Sine Center / Sine bar / bevel protractor
10	Measurement of alignment using Autocollimator / Roller set
11	Measurement of Screw threads Parameters using Two-wire or Three-wire method.
12	Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator
13	Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer
14	Calibration of Micrometer using slip gauges

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

- CO1: Identify and classify different measuring tools related to experiments.
- CO2: Identify, define, and explain accuracy, resolution, precision, and some additional terminology.
- CO3: 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - IV

COMPUTER AIDED AIRCRAFT DRAWING

Course Code	**18AEL48/18ASL48**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
	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.
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.
	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.
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.
5	**Keys & Joints:** Parallel key, Taper key, Feather key, Gibhead key and Woodruff key
6	**Riveted Joints:** Single and double riveted lap joints, butt joints with single/double cover straps (Chain
7	**Couplings:** Split Muff coupling, protected type flanged coupling, pin (bush) type flexible coupling, Oldham's coupling and universal coupling (Hooks' Joint)
	PART C
8	Modelling of propeller and hub assembly
9	Modelling of wing assembly
10	Modelling of fuselage assembly
11	Modelling of Engine Mounts
12	Modelling of main rotor blade assembly of helicopter
13	Modelling of UAV assembly
14	Modelling of Landing Gear Assembly

Course outcomes:

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

- CO1 :Distinguish drawings of machine and aircraft components
- CO2 :Identify assembly drawings either manually or by using standard CAD packages.
- CO3 :Practice with standard components and their assembly of an aircraft.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E.(Common to all Programmes)
Outcome Based Education (OBE) and Choice Based Credit System (CBCS)
SEMESTER - IV

ADDITIONAL MATHEMATICS – II
(Mandatory Learning Course: Common to All Programmes)
(A Bridge course for Lateral Entry students under Diploma quota to BE/B.Tech. programmes)

Course Code	**18MATDIP41**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(2:1:0)	SEE Marks	60
Credits	**0**	Exam Hours	03

Course Learning Objectives:

- To provide essential concepts of linear algebra, second & higher order differential equations along with methods to solve them.
- To provide an insight into elementary probability theory and numerical methods.

Module-1

Linear Algebra: Introduction - rank of matrix by elementary row operations - Echelon form. Consistency of system of linear equations - Gauss elimination method. Eigen values and Eigen vectors of a square matrix. Problems.

Module-2

Numerical Methods: Finite differences. Interpolation/extrapolation using Newton's forward and backward difference formulae (Statements only)-problems. Solution of polynomial and transcendental equations – Newton-Raphson and Regula-Falsi methods (only formulae)- Illustrative examples. Numerical integration: Simpson's one third rule and Weddle's rule (without proof) Problems.

Module-3

Higher order ODE's: Linear differential equations of second and higher order equations with constant coefficients. Homogeneous /non-homogeneous equations. Inverse differential operators.*[Particular Integral restricted to R(x)=* e^{ax}, sin *ax* /cos *ax for* $f(D)y = R(x)$.]

Module-4

Partial Differential Equations(PDE's):- Formation of PDE's by elimination of arbitrary constants and functions. Solution of non-homogeneous PDE by direct integration. Homogeneous PDEs involving derivative with respect to one independent variable only.

Module-5

Probability: Introduction. Sample space and events. Axioms of probability. Addition & multiplication theorems. Conditional probability, Bayes's theorem, problems.

Course Outcomes:
At the end of the course the student will be able to:
CO1:Solve systems of linear equations using matrix algebra.
CO2: Apply the knowledge of numerical methods in modelling and solving engineering problems.
CO3: Make use of analytical methods to solve higher order differential equations.
CO4: Classify partial differential equations and solve them by exact methods.
CO5: Apply elementary probability theory and solve related problems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook				
1	Higher Engineering Mathematics	B.S. Grewal	Khanna Publishers	43rd Edition, 2015
Reference Books				
1	Advanced Engineering Mathematics	E. Kreyszig	John Wiley & Sons	10th Edition, 2015
2	Engineering Mathematics	N. P. Bali and Manish Goyal	Laxmi Publishers	7th Edition, 2007
3	Engineering Mathematics Vol. I	Rohit Khurana	Cengage Learning	1st Edition, 2015

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

MANAGEMENT AND ENTREPRENEURSHIP

Course Code	**18AE51/18AS51**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic concepts of management, planning, organizing and staffing.
- Acquire the knowledge to become entrepreneur.
- Comprehend the requirements towards the small-scale industries and project preparation.

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.

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.

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 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.

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

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

1. CO1: Explain about the management and planning.
2. CO2: Apply the knowledge on planning, organizing, staffing, directing and controlling.
3. CO3: Describe the requirements towards the small-scale industries and project preparation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
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	Pearson Education	2006
Reference Books				
1	Management Fundamentals-Concepts, Application, Skill Development	RobersLusier-Thomson		
2	Entrepreneurship Development	S.S. Khanka	S. Chand & Co	
3	Management	Stephen Robbins	Pearson Education	17th Edition,2003

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

AERODYNAMICS - II

Course Code	**18AE52/18AS52**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:1:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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. Basics of Fanno and Rayleigh Flow.

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 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.

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

1. CO1: Utilize the concepts of compressible flow and shock phenomenon
2. CO2: Apply knowledge of oblique shock and expansion wave formation.
3. CO3: Measure the parameters high speed flow.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Modern Compressible Flow	John D Anderson	Mc Graw Hill	3rd edition, 2012
2	Gas Dynamics	Radhakrishnan, E	Prentice Hall of India	5th edition,2014
Reference Books				
1	Dynamics and Thermodynamics of Compressible fluid flow	Ascher. H. Saphiro	John Wiley & Sons	1st edition,1977
2	Fundamentals of Compressible flow	Yahya, S.M	NEW AGE	2009
3	Elements of Gas Dynamics	H.W. Liepmann and A. Roshko	Dover Publications Inc	2003
4	Compressible Fluid Dynamics with Computer Application	Hodge B. K, Koenig K	Prentice Hall, New York	1st edition,1995
5	Elements of gas dynamics	Zucrow, M.J. and Anderson, J.D	McGraw - Hill Book Co., New York	1989

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

AIRCRAFT STRUCTURES - I

Course Code	**18AE53**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:1:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

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.

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 and its effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.

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. Desirable properties for aircraft application.

Module-4

Theory of Elasticity and Structures:

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.

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.

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

1. CO1: Apply the basic concepts of stress and strain analysis.
2. CO2: Compute the impact stress.
3. CO3: Identify appropriate materials for suitable application based on properties.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Aircraft Structures for Engineering Students	**Megson, T.M.G**	Edward Arnold	1995
2	Theory of Elasticity	**Timoshenko and Goodier**	McGraw Hill Co	
3	Design of Machine Elements	**V.B. Bhandari**	Tata McGraw Hill Publishing CompanyLtd., New Delhi	2nd Edition 2007
Reference Books				
1	Machine Design	**Robert L. Norton**	Pearson Education Asia	2001
2	Analysis of Aircraft Structures – An Introduction	**Donaldson, B.K**	McGraw-Hill	1993
3	Strength of Materials	**Timoshenko, S**	Princeton D Von Nostrand Co	1990
4	Mechanical Engineering Design	**Joseph E Shigley and Charles R.Mischke**	McGraw Hill International	6th Edition 2009
5	Aircraft Structures	**Peery, D.J., and Azar, J.J**	McGraw, Hill	2nd edition,1993
6	Analysis and Design of Flight Vehicles Structures	**Bruhn. E.H**	Tri – state off set company, USA	1985

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

INTRODUCTION TO COMPOSITE MATERIALS

Course Code	**18AE54**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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

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.

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 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.

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.

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

1. CO1: Explain the advantages of using composite materials as an alternative to conventional materials for specific applications
2. CO2: Describe the advanced fabrication and processing for producing composite parts.
3. CO3: Evaluate the micro- and macro-mechanical behavior of composite laminates

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Composite Materials- Science and Engineering	**K.K Chawla**	Springer Verlag	II edition,1998
2	Mechanics of Composites	**Autar Kaw**	CRC Press	II edition,2006
Reference Books				
1	Composite Materials Handbook	**Mein Schwartz**	Department of Defense, USA	2002
2	Non-Destructive Testing of Composite Materials	**Ajay Kapadia**	TWI Publications	2006
3	Mechanics of Composite Materials	**R M Jones**	Taylor & Francis	2nd Edn,2015

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

AIRCRAFT SYSTEMS & INSTRUMENTATION

Course Code	**18AE55/18AS55**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the aircraft control systems.
- Understand the aircraft systems.
- Acquire the knowledge of aircraft instruments.

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 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.

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.

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.

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.

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

1. CO1: Distinguish the conventional and modern control systems.
2. CO2: Classify the aircraft systems.
3. CO3: Categorize different types of aircraft instruments.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbooks				
1	Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem Integration	Ian Moir and Allan Seabridge	Wiley India Pvt Ltd	3rd edition, 2012
2	Aircraft Instruments and Integrated Systems	Pallet, E.H.J	Longman Scientific and Technical	1996

Reference Books				
1	Aircraft Systems (Fundamentals of Flight Vol. IV)	Lalit Gupta and OP. Sharma	Himalayan Books	2006
2	Gas Turbine Technology	Treager. S	McGraw-Hill	3rd edition,2013
3	TheaircraftEngineersHandbook,No4 , Instruments	R.W. Sloley and W.H. Coulthard		6th Edition,2005
4	Pneumatic Systems	SR. Majumdar	Tata McGraw Hill Publishing Co	1stEdition,2001
5	Aircraft Hydraulic Systems	William A Neese	Himalayan Books	2007

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

THEORY OF VIBRATIONS

Course Code	**18AE56**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

Module-1

Introduction: Types of vibrations, S.H.M, principle of super position applied to Simple Harmonic Motions. Beats, Fourier theorem and simple problems.

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.

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 excitation and support motion.
Vibration Measuring Instruments & Whirling of Shafts: Vibration of elastic bodies – Vibration of strings – Longitudinal, lateral and torsional Vibrations.

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: Vehicle suspension, Dynamic vibration absorber and Dynamics of reciprocating Engines.
Continuous Systems: Introduction, vibration of string, longitudinal vibration of rods, Torsional vibration of rods, Euler's equation for beams.

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.

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

1. CO1: Apply the principle of super position to Simple Harmonic Motions.
2. CO2: Determine the vibrations using vibration instruments.
3. CO3: Analyze the multi-degree freedom systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Theory of Vibration with Applications	W.T. Thomson and Marie Dillon Dahleh	Pearson Education	5^{th} edition, 2008
2	Mechanical Vibrations	V.P. Singh	DhanpatRai& Company Pvt. Ltd	2016
Reference Books				
1	Mechanical Vibrations	S.S. Rao	Pearson Education Inc	4th Edition,2003
2	Mechanical Vibrations	S. Graham Kelly	Tata McGraw Hill	Special Indian edition, 2007
3	Theory & Practice of Mechanical vibrations	J.S. Rao & K. Gupta	New Age International Publications, New Delhi	2001
4	Elements of Vibrations Analysis	Leonanrd Meirovitch	Tata McGraw Hill	Special Indian edition, 2007

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

AERODYNAMICS LAB

Course Code	**18AEL57/18ASL57**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Calibration of a subsonic wind tunnel: test section static pressure and total head distributions.
2	Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds.
3	Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds
4	Smoke flow visualization studies on a two dimensional multi element airfoil with flaps and slats at different angles of incidence at low speeds
5	Tuft flow visualization on a wing model at different angles of incidence at low speeds: identify zones of attached and separated flows.
6	Surface pressure distributions on a two-dimensional smooth circular cylinder at low speeds and calculation of pressure drag.
7	Surface pressure distributions on a two-dimensional rough circular cylinder at low speeds and calculation of pressure drag.
8	Surface pressure distributions on a two-dimensional symmetric airfoil and estimation of center of
9	Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence,
10	Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey.
11	Calculation of total drag of a two-dimensional cambered airfoil at low speeds at incidence using pitot-static probe wake survey.
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.
13	Calculation of aerodynamic coefficients and forces acting on a model aircraft at various Angle of Attack and speeds using wind tunnel balance (With and Without Yaw).
14	Pressure measurements on aerofoil for a case of reverse flow.

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

1. CO1: Apply the flow visualization techniques.
2. CO2: Estimate the pressure distribution over the bodies.
3. CO3: Calculate the lift and drag.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - V

ENERGY CONVERSION AND FLUID MECHANICS LAB

Course Code	18AEL58	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Determination of Flash point and Fire point of lubricating oil using Abel Pensky and Pensky Martins Apparatus.
2	Determination of Calorific value of solid, liquid and gaseous fuels
3	Determination of Viscosity of lubricating oil using Torsion viscometer.
4	Valve Timing diagram of 4-stroke IC Engine
5	Calculation of work done and heat transfer from PV and TS diagram using Planimeter
6	Performance Test on **Four stroke Petrol Engine** and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet.
7	Performance Test on Four stroke Multi-cylinder Engine and calculations of IP, BP, Thermal efficiencies, SFC, FP and to draw heat balance sheet.
8	Calibration of Venturimeter
9	Determination of Coefficient of discharge for a small orifice by a constant head method.
10	Determination of Viscosity of a Fluid
11	Calibration of contracted Rectangular Notch
12	Verification of Bernoulli's equation.
13	Pipe friction apparatus with loss of head on pipe fittings
14	Determination of Coefficient of loss of head in a sudden contraction and friction factor.

Course outcomes:

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

1. CO1 :Operate the instrument and measure the BP, FP, IP and AF ratio.
2. CO2 :Find the efficiency of the engine and Estimate the calorific value of the given fuel.
3. CO3 :Verify the Bernoulli's equation.
4. CO4 : Evaluate the viscosity of fluid.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.■

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – V

ENVIRONMENTAL STUDIES

Course Code	**18CIV59**	CIE Marks	40
Teaching Hours / Week (L:T:P)	(1:0:0)	SEE Marks	60
Credits	01	Exam Hours	02

Module - 1

Ecosystems (Structure and Function): Forest, Desert, Wetlands, Riverine, Oceanic and Lake.
Biodiversity: Types, Value; Hot-spots; Threats and Conservation of biodiversity, Forest Wealth, and Deforestation.

Module - 2

Advances in Energy Systems (Merits, Demerits, Global Status and Applications)**:** Hydrogen, Solar, OTEC, Tidal and Wind.
Natural Resource Management (Concept and case-studies): Disaster Management, Sustainable Mining, Cloud Seeding, and Carbon Trading.

Module - 3

Environmental Pollution (Sources, Impacts, Corrective and Preventive measures, Relevant Environmental Acts, Case-studies)**:** Surface and Ground Water Pollution; Noise pollution; Soil Pollution and Air Pollution.
Waste Management & Public Health Aspects: Bio-medical Wastes; Solid waste; Hazardous wastes; E-wastes; Industrial and Municipal Sludge.

Module - 4

Global Environmental Concerns (Concept, policies and case-studies):Ground water depletion/recharging, Climate Change; Acid Rain; Ozone Depletion; Radon and Fluoride problem in drinking water; Resettlement and rehabilitation of people, Environmental Toxicology.

Module - 5

Latest Developments in Environmental Pollution Mitigation Tools (Concept and Applications): G.I.S. & Remote Sensing, Environment Impact Assessment, Environmental Management Systems, ISO14001; Environmental Stewardship- NGOs.
Field work: Visit to an Environmental Engineering Laboratory or Green Building or Water Treatment Plant or Waste water treatment Plant; ought to be Followed by understanding of process and its brief documentation.

Course Outcomes: At the end of the course, students will be able to:

- CO1: Understand the principles of ecology and environmental issues that apply to air, land, and water issues on a global scale,
- CO2: Develop critical thinking and/or observation skills, and apply them to the analysis of a problem or question related to the environment.
- CO3: Demonstrate ecology knowledge of a complex relationship between biotic and abiotic components.
- CO4: Apply their ecological knowledge to illustrate and graph a problem and describe the realities that managers face when dealing with complex issues.

Question paper pattern:

- The Question paper will have 100 objective questions.
- Each question will be for 01 marks
- Student will have to answer all the questions in an OMR Sheet.
- The Duration of Exam will be 2 hours.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Environmental Studies	Benny Joseph	Tata Mc Graw – Hill.	2nd Edition, 2012
2.	Environmental Studies	S M Prakash	Pristine Publishing House, Mangalore	3rd Edition, 2018
3	Environmental Studies – From Crisis to Cure	R Rajagopalan	Oxford Publisher	2005
Reference Books				
1	Principals of Environmental Science and Engineering	Raman Sivakumar	Cengage learning, Singapur.	2nd Edition, 2005
2	Environmental Science – working with the Earth	G.Tyler Miller Jr.	Thomson Brooks /Cole,	11th Edition, 2006
3	Text Book of Environmental and Ecology	Pratiba Sing, Anoop Singh& Piyush Malaviya	Acme Learning Pvt. Ltd. New Delhi.	1st Edition

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VI

AIRCRAFT PERFORMANCE

Course Code	**18AE61**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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 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.

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.

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

1. CO1: Apply the basic airplane performance parameters.
2. CO2: Differentiate the aircraft performance in steady unaccelerated and accelerated flight.
3. CO3: Explain the aircraft maneuver performance.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft Performance and Design	**John D. Anderson, Jr**	McGraw-Hill International	Aerospace Science/ Technology Editions, 1999
2	Introduction to flight	**John D. Anderson, Jr**	McGraw-Hill International	Aerospace Science/ Technology Editions, 2000
Reference Books				
1	Airplane Performance stability and Control	**Perkins, C.D., and Hage, R.E**	John Wiley Son Inc, New York	1988
2	Aerodynamics, Aeronautics, and Flight Mechanics	**Barnes W. McCormick**	John Wiley Son Inc, New York	1995

B.E AERONAUTICAL ENGINEERING
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SEMESTER - VI

AIRCRAFT STRUCTURES - II

Course Code	**18AE62**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

Module-1

Bending of 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.

Module-2

Shear and Torsion of Open and Closed Thin Walled 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. Combined bending, shear, torsion.

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 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

Design Criteria and **Structural Idealization**
Design Criteria, Safety Factor, Design life criteria, Analysis method, Life Assessment procedures, Design Principle, Two bay crack criteria, Widespread Fatigue damage.
Structural Idealization
StructuralidealizationPrinciple,Idealizationofapanel,effectofidealizationontheanalysisofopenandclosedsectionbeams.Bendingofopenandclosedsectionidealizedbeams,shearofopensectionandclosedsectionidealizedbeams.Deflectionofopenand closed section idealized beams.

Module-5

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.
Stress Analysis in Fuselage Frames
Bending, shear, torsion, cut-outs in fuselages, principles of stiffeners construction, fuselage frames, shear flow distribution.

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

1. CO1: Utilize the concepts of thin walled beams.
2. CO2: Calculate the buckling of plates.
3. CO3: Analysis the stress in wings and fuselage frames.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft Structures for Engineering Students	Megson, T. H. G	Edward Arnold	1995
2	Aircraft Structures	Peery D J & Azar J J	McGraw Hill N.Y	2nd edition,1993
Reference Books				
1	Analysis & Design of Flight Vehicles Structures	Bruhn E. F	Tri-State offset Co, USA	1985
2	Introduction to Aircraft Structural Analysis	Megson, T. H. G	Elsevier	2nd Edition, 2014
3	Analysis of Aircraft Structures	Bruce K Donaldson	Cambridge Aerospace Series	1992

B.E AERONAUTICAL ENGINEERING
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SEMESTER - VI

FINITE ELEMENT METHOD

Course Code	**18AE63/18AS63**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:2:0)	SEE Marks	60
Credits	04	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

Module-5

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

1. CO1: Apply discretisation technique for domain decomposition.
2. CO2 :Evaluate the effects of different loading and boundary conditions
3. CO3 : Analyze the governing equations of finite element analysis

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Finite Elements in engineering	Chandrupatla T. R	PHI	3rd edition, 2002
2	Finite element Analysis	Bhavikatti	New Age International	3rd edition,2015
Reference Books				
1	Finite element analysis in engineering design	Rajasekharan. S	Wheeler Publishers	
2	Finite Element Procedures	Bathe. KJ	PHI Pvt. Ltd., New Delhi	1996
3	The Finite Element Method	Zienkiewicz. O.C	Elsevier	7th edition,2013
4	Finite Elements Method in Engineering	Rao S. S	Elsevier	5th edition, 2008
5	Finite Element analysis - Theory and Programming	C.S. Krishnamurthy	Tata McGraw Hill Co. Ltd, New Delhi	2nd edition,2011

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SEMESTER - VI

AIRCRAFT TRANSPORTATION SYSTEMS

Course Code	**18AE641**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

Module-1

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.

Module-2

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.

Module-3

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.

Module-4

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.

Module-5

Managerial Aspects of Airlines

Airline passenger marketing, forecasting methods, pricing and demand. Air cargo-market for air freight. Principles of airline scheduling. Fleet planning.

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

- CO1: Explain the air transport systems.
- CO2: Describe the aircraft characteristics, airlines and airport operation.
- CO3: Apply the Air Navigation System & Environmental Systems.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	Air Transport System	Dieter Shmitt, and ValkerGollnick	Springer	2016
2	Air Transportation-A Management Prospective	Jhon G Wensveen	Ashgate Publishing Ltd	2011
Reference Books				
1	The Air Transportation System	Mike Hirst	Woodhead Publishing Ltd, England	2008

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SEMESTER - VI

NUMERICAL METHODS

Course Code	**18AE642**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

Module-4

Curve Fitting
Motivation and objectives/ Interpolation/ Newton's Difference Formula/ Cubic Splines/ Least Square/ Two-Dimensional Interpolation.

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.

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

1. CO1: Apply the basic concepts of numerical methods.
2. CO2: Compute the Eigen values, Eigen vectors, numerical differentiation and integration.
3. CO3: Perform the curve fitting and root finding.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Applied Numerical methods for Engineers Using Mat Lab and C	Robert Schilling and Sandra Harris	Thomson Learning	2002
2	Applied Numerical Analysis	Gerald and Wheatley	Pearson Education	2002
Reference Books				
1	Numerical Methods: For Scientific and Engineering Computation	Mahinder Kumar Jain	New Age Publishers	2012
2	Numerical Methods for Engineering and Science	Rajesh Srivastava and SaumyenGuha	Oxford University Press	2010
3	Numerical Methods	P. Kandasamy, K. Thilagavathy and K. Gunavathi	Chand Publishers	2006

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SEMESTER - VI

ARTIFICIAL INTELLIGENCE& EXPERT SYSTEMS

Course Code	**18AE643**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic techniques of artificial intelligence.
- Understand the Non-monotonic reasoning and statistical reasoning.
- Acquire the knowledge on filler structures, and understanding.

Module-1

AI: The AI Problems, The Underlying Assumption, What Is An AI Techniques, The Level Of The Model, Criteria For Success, Some General References, One Final Word.
Problems, State Space Search & Heuristic Search Techniques: Defining The Problems As A State Space Search, Production Systems, Production Characteristics, Production System Characteristics, And Issues In The Design Of Search Programs, Additional Problems. Generate-And-Test, Hill Climbing, Best-First Search, Problem Reduction, Constraint Satisfaction, Means-Ends Analysis

Module-2

Knowledge Representation Issues: Representations And Mappings, Approaches To Knowledge Representation.
Using Predicate Logic : Representation Simple Facts In Logic, Representing Instance And Isa Relationships, Computable Functions And Predicates, Resolution
Representing Knowledge Using Rules: Procedural Versus Declarative Knowledge, Logic Programming, Forward Versus Backward Reasoning.

Module-3

Symbolic Reasoning Under Uncertainty: Introduction To Nonmonotonic Reasoning, Logics For Non-monotonic Reasoning. Turning performance limitations. Drag estimation. Take-off and landing - methods, procedures and data reduction.
Statistical Reasoning: Probability And Bays' Theorem, Certainty Factors And Rule-Base Systems, Bayesian Networks, DempsterShafer Theory, Fuzzy Logic.

Module-4

Weak Slot-and-Filler Structures : Semantic Nets, Frames.
Strong Slot-and-Filler Structures : Conceptual Dependency, Scripts, CYC.
Game Playing: Overview, And Example Domain : Overview, MiniMax, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components Of A Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical Planning, Reactive Systems, Other Planning Techniques

Module-5

Understanding: What is understanding? , What makes it hard?, As constraint satisfaction.
Natural Language Processing: Introduction, Syntactic Processing, Semantic Analysis, Semantic Analysis, Discourse And Pragmatic Processing, Spell Checking.
Connectionist Models : Introduction: Hopfield Network, Learning In Neural Network, Application Of Neural Networks, Recurrent Networks, Distributed Representations, Connectionist AI And Symbolic AI

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

1. CO1: Apply the basic techniques of artificial intelligence.
2. CO2: Distinguish Non-monotonic reasoning and statistical reasoning.
3. CO3: Evaluate the natural language processing and connectionist models.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Artificial Intelligence	Elaine Rich And Kevin Knight	Tata Mcgraw-Hill	3rd edition,2008
2	Artificial Intelligence- A Modern Approach	Stuart Russel, Peter Norvig	PEI	3rd edition,2015
Reference Books				
1	Introduction to Prolog Programming	Carl Townsend		
2	PROLOG Programming For Artificial Intelligence	Ivan Bratko(Addison-Wesley)	PEI	3rd edition,2002
3	Programming with PROLOG	Clocksin and Mellish	Springer	5th edition, 2003

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SEMESTER - VI

GAS TURBINE TECHNOLOGY

Course Code	**18AE644**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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 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.

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

1. CO1: Select the suitable materials for engine manufacturing.
2. CO2: Evaluate the performance of the engine.
3. CO3: Test the engine using several types of engine testing methods.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Gas Turbine Engine Technology	Irwin E. Treager	McGraw Hill Education	3rd edition,2013
2	Gas Turbine Performance	P. P Walshand P. Peletcher	Blackwell Science	1998
Reference Books				
1	Advanced Aero-Engine Testing	A. W. Morley Jean Fabri	Pergamon	1959
2	Military Specifications: Engine, Aircraft, Turbo Jet &Turbofan; General Specification for Advance Aero Engine testing			1973
3	Experimental methods for Engineers	JP Holman	Tata Mc Graw Hill	7th edition,2007
4	Turbomachinery Dynamics-Design and operations	A SRangawala	McGraw–Hill	2005
5	Aircraft Power Plant	Michael J. Kores, and Thomas W. Wild	Tata Mc Graw Hill Publishing Co. Ltd	7thEdition,2002

B.E AERONAUTICAL ENGINEERING
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SEMESTER - VI

AIRCRAFT PROPULSION LAB

Course Code	**18AEL66**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Study of an aircraft piston engine. (Includes study of assembly of sub systems, various components, their functions and operating principles)
2	Study of an aircraft jet engine (Includes study of assembly of sub systems, various components, their functions and operating principles)
3	Study of forced convective heat transfer over a flat plate.
4	Cascade testing of a model of axial compressor blade row.
5	Cascade testing of a model of axial Turbine blade row
6	Study of performance of a propeller.
7	Determination of heat of combustion of aviation fuel.
8	Study of free and wall jet
9	Measurement of burning velocity of a premixed flame.
10	Study of the flame lift up and fall back phenomenon for varied Air/Fuel ratio.
11	Measurement of nozzle flow.
12	Performance studies on a scaled jet engine
13	Investigation of pressure distribution and relationship between inlet pressure/outlet pressure and mass flow rate in a convergent-divergent nozzle when working over a variety of overall pressure ratios including under-expanding and over-expanding conditions.
14	Investigation of pressure distribution and relationship between inlet pressure/outlet pressure and mass flow rate in a convergent-divergent nozzle under choked conditions.

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

1. CO1: Analyze the cascade testing of axial compressor and axial turbine blade row.
2. CO2: Evaluate the performance of a jet engine.
3. CO3: 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

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SEMESTER - VI

AIRCRAFT STRUCTURES LAB

Course Code	**18AEL67**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

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

Sl. No.	Experiments
1	Deflection of a Simply Supported Beam.
2	Deflection of a cantilever Beam
3	Beam with combined loading by using superposition theorem
4	Verification of Maxwell's Reciprocal Theorem for beam with a). Constant cross section b). Varying Cross section
5	Determination of Young's Modulus using strain gages.
6	Poisson Ratio Determination
7	Buckling load of slender Eccentric Columns and Construction of Southwell Plot
8	Shear Failure of Bolted and Riveted Joints
9	Bending Modulus of sandwich Beam
10	Tensile, Compressive and Flexural testing of a composite material plate.
11	Determination of natural frequency and mode shapes of a cantilever beam for the following cases. a. Constant cross section b. Varying cross section c. Constant cross section and varying stiffness
12	Determination of shear centre for following cases through deflection measurements. a. Close section – Symmetrical bending b. Open section – Unsymmetrical bending
13	Determination of shear flow for following cases. a. Close section – Symmetrical bending b. Open section – Unsymmetrical bending
14	Determining of Shear centre through shear flow measurement for following cases. a. Close section – Symmetrical bending **b.** Open section – Unsymmetrical bending

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

1. CO1: Compute the deflection of simply supported beam and cantilever beam.
2. CO2: Verify the Maxwell's theorem.
3. CO3: 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Open Electives

B.E AERONAUTICAL ENGINEERING **Choice Based Credit System (CBCS) and Outcome Based Education (OBE)** **SEMESTER – VI** **Open Elective - A**			
HISTORY OF FLIGHT & TECHNOLOGY FORECAST			
Course Code	**18AE651/18AS651**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03
Course Learning Objectives: • Study the basic concepts of flying. • Understand about the aircraft structures and materials. • 3. Acquire the knowledge of aircraft power plants.			
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.			
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.			
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.			
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.			
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.			
Course outcomes: At the end of the course the student will be able to: 1. CO1: Identify the aspects of aircrafts. 2. CO2: Classify the aircraft materials. 3. CO3: Describe the instruments and power plants used in airplanes.			
Question paper pattern: • The question paper will have ten full questions carrying equal marks. • Each full question will be for 20 marks. • There will be two full questions (with a maximum of four sub- questions) from each module. • Each full question will have sub- question covering all the topics under a module. • The students will have to answer five full questions, selecting one full question from each module.			

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to Flight	Anderson, J.D	McGraw-Hill	1995
2	Introduction to Aeronautics: A design perspective	Stephen. A. Brandt	AIAA Education Series	2nd Edition,2004
Reference Books				
1	Mechanics of Flight	Kermode, A.C	Himalayan Book	1997
2	Flight without Formula	Kermode, A.C	Pearson	2009

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VI
Open Elective - A

ELEMENTS OF JET PROPULSION SYSTEMS

Course Code	**18AE652/18AS652**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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.

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

1. CO1: Apply the basic principle and theory of aircraft propulsion.
2. CO2 : Explain the functions of centrifugal, axial compressors, axial and radial turbines
3. CO3 : Analyse the performance of nozzles & inlets and combustion chamber

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft propulsion	Bhaskar Roy	Elsevier	2011
2	Gas Turbines	V. Ganesan	Tata McGraw-Hill, New Delhi	2010
Reference Books				
1	Mechanics & Thermodynamics of Propulsion	Hill, P.G. & Peterson, C.R	Addison –Wesley Longman INC	1999
2	Gas Turbine Theory	Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H	Longman	1989
3	Gas Turbine Engine Technology	Irwin E. Treager	Tata McGraw Hill Publishing Co. Ltd	7th Edition,2003
4	Fundamentals of Compressible Flow with Aircraft and Rocket propulsion	S. M. Yahya	New Age International Publications, New Delhi	4th Edition,2014

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VI
Open Elective - A

BASICS OF ROCKETS & MISSILES

Course Code	**18AE653/18AS653**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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 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.

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.

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

1. CO1: Identify the types of space launch vehicles and missiles.
2. CO2: Distinguish the solid and liquid propellant motors.
3. CO3: Classify different types of materials used for rockets and missies.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Rocket Propulsion Element	George P Sutton and Oscar Biblarz	John Wiley and Sons Inc	7th edition, 2010
2	Missile Aerodynamics	Jack N Neilson	AIAA	1st edition, 1988
Reference Books				
1	Missile Configuration Design	SS. Chin	McGraw Hill	1961
2	Rocket Propulsion and Space-Flight Dynamics	Cornelisse, J.W, Schoyer H.F.R. and Wakker, K.F	Pitman	1979
3	Rocket and Spacecraft propulsion	Turner, M.J.L	Springer	3rd edition, 2010
4	Space Vehicle Dynamics	Ball, K.J., Osborne, G.F	Oxford University Press	1967
5	Materials for Missiles and Spacecraft	Parker, E.R	McGraw Hill	1982

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

AIRCRAFT STABILITY AND CONTROL

Course Code	**18AE71**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basics of aircraft static stability and control.
- Understand the EOMs and stability parameters.
- Acquire the knowledge on dynamic longitudinal, lateral and directional stability.

Module-1

Static Longitudinal Stability and Control-Stick Fixed

Definition, 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 required for landing, Restriction on forward C.G. range.

Module-2

Static Longitudinal 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.

Module-3

Static Directional and Lateral Stability and Control

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.

Static Lateral 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.

Module-4

Equations of Motions

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, 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 Stability

Dynamic longitudinal stability. Types of modes of motion: phugoid motion, short period motion. Routh's stability criteria. Factors affecting period and damping of oscillations. Flying qualities in pitch. Cooper-Harper Scale. Dynamic lateral and directional stability. Response to aileron step-function, side-slip excursion. Dutch roll and Spiral instability. Auto- rotation and spin. Stability derivatives for lateral and directional dynamics.

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

1. CO1: Apply the concepts of aircraft static stability and control.
2. CO2: Formulate EOMs and analyse stability parameters.
3. CO3 : Apply the knowledge of dynamic stability

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Airplane Performance stability and Control	Perkins, C.D., and Hage, R.E	John Wiley , New York	1998
2	Flight Stability and Automatic Control	Nelson, R.C	McGraw-Hill Book Co	2007
Reference Books				
1	Performance, Stability, Dynamics and Control of Airplanes	Bandu N. Pamadi	AIAA	2nd Edition,2004
2	Introduction to flight	John D. Anderson, Jr	McGraw-Hill	Aerospace Science Technology Editions, 2000
3	The Principles of the Control and Stability of Aircraft	W.J. Duncan	Cambridge University Press	2016

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

COMPUTATIONAL FLUID DYNAMICS

Course Code	**18AE72**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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.

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

1. CO1 :Differentiate the FDM, FVM and FEM
2. CO2: Perform the flow, structural and thermal analysis.
3. CO3: Utilize the discretization methods according to the application.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Applied Computational Fluid Dynamics	Gupta S.C	Wiley, India	2019
2	Computational Fluid Dynamics	John D. Anderson	McGraw Hill	2013
Reference Books				
1	Computational Fluid Dynamics-An Introduction	John F. Wendt	Springer	3rd Edition, 2013
2	Numerical Computation of Internal and External Flows	Charles Hirsch	Elsevier	1st edition,2007
3	Computational Fluid Dynamics for Engineers	Klaus A Hoffmann and SteveT. Chiang		1993
4	Fundamentals of CFD	Tapan K. Sengupta	Universities Press	2004

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VII

FATIGUE AND FRACTURE MECHANICS

Course Code	**18AE731**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basics of fatigue of structures.
- Comprehend the fracture mechanics.
- Acquire the knowledge of fatigue design and testing.

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.

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.

Module-3

Physical Aspects of Fatigue: Phase in fatigue life, Crack initiation, Crack growth, Final fracture, Dislocations, Fatigue fracture surfaces.

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.

Module-5

Fatigue Design and Testing: Safe life and fail safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application to composite materials and structures.

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

1. CO1: Evaluate the fatigue of structures.
2. CO2: Determine the strength of cracked bodies.
3. CO3: Distinguish the safe life and fail safe design.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Elementary Engineering Fracture Mechanics	D. Brock	Noordhoff International Publishing Co., London	1994
2	Fundamentals of Fracture Mechanics	J.F.Knott	Butterworth & Co., Publishers Ltd., London	1983

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

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

CONTROL ENGINEERING

Course Code	**18AE732**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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.

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

1. CO1: Apply the concepts of control systems.
2. CO2: Reduce the block diagrams and signal flow graphs.
3. CO3: Determine the frequency response analysis by using various types of plots.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Control Engineering	U.A. Bakshi and V.U. Bakshi	Technical Publications	
2	Control Systems Engineering	A. NagoorKani	RBA Publications	2014
Reference Books				
1	Modern Control Engineering	Katsuhiko Ogatta	Pearson Education	2004
2	Control Systems Engineering	I.J. Nagrath and M. Gopal	New Age Publishers	2017
3	Modern Control Systems	Richard. C. Dorf and Robert.H. Bishop	Addison Wesley	1999
4	Control Systems Engineering	N.S. Nise	Wiley	6th Edition,2012

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

HYDRAULICS & PNEUMATICS

Course Code	**18AE733**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic concepts of Hydraulic systems.
- Acquire the knowledge on control components, Hydraulic Circuit design and analysis.
- Understand the Pneumatic control and its systems.

Module-1

Introduction to Hydraulic Power: Definition of hydraulic system, advantages, limitations, applications, Pascal's law, structure of hydraulic control system, problems on Pascal's law.
The source of Hydraulic Power: Pumps Classification pumps, Pumping theory of positive displacement pumps, construction and working of Gear pumps, Vane pumps, Piston pumps, fixed and variable displacement pumps, Pump performance characteristics, pump Selection factors, problems on pumps.
Hydraulic Actuators and Motors: Classification cylinder and hydraulic motors, Linear Hydraulic Actuators [cylinders], single and double acting cylinder, Mechanics of Hydraulic Cylinder Loading, mounting arrangements, cushioning, special types of cylinders, problems on cylinders, construction and working of rotary actuators such as gear, vane, piston motors, Hydraulic Motor Theoretical Torque, Power and Flow Rate, Hydraulic Motor Performance, problems, symbolic representation of hydraulic actuators (cylinders and motors).

Module-2

Control Components in Hydraulic Systems: Classification of control valves, Directional Control Valves- Symbolic representation, constructional features of poppet, sliding spool, rotary type valves solenoid and pilot operated DCV, shuttle valve, check valves, Pressure control valves- types, direct operated types and pilot operated types. Flow Control Valves- compensated and non-compensated FCV, needle valve, temperature compensated, pressure compensated, pressure and temperature compensated FCV, symbolic representation.

Module-3

Hydraulic Circuit Design And Analysis: Control of Single and Double Acting Hydraulic Cylinder, Regenerative circuit, Pump Unloading Circuit, Double Pump Hydraulic System, Counter balance Valve Application ,Hydraulic Cylinder Sequencing Circuits, Automatic cylinder reciprocating system, Locked Cylinder using Pilot check Valve, Cylinder synchronizing circuit using different methods, factors affecting synchronization, Hydraulic circuit for force multiplication, Speed Control of Hydraulic Cylinder, Speed Control of Hydraulic Motors, Safety circuit, Accumulators, types, construction and applications with circuits.

Module-4

Maintenance of Hydraulic System: Hydraulic Oils-Desirable properties, general type of Fluids, Sealing Devices, Reservoir System, Filters and Strainers, wear of Moving Parts due to solid-particle Contamination, temperature control (heat exchangers), Pressure switches, trouble shooting.

Introduction to Pneumatic Control: Definition of pneumatic system, advantages, limitations, applications, Choice of working medium. Characteristic of compressed air. Structure of Pneumatic control System, fluid conditioners and FRL unit.

Pneumatic Actuators: Linear cylinder-Types, Conventional type of cylinder- working, End position cushioning, seals, mounting arrangements-Applications. Rod-Less cylinders types, working, advantages, Rotary cylinders-types construction and application, symbols.

Module-5

Pneumatic Control Valves: DCV such as poppet, spool, suspended seat type slide valve, pressure control valves, flow control valves, types and construction, use of memory valve, Quick exhaust valve, time delay valve, shuttle valve, twin pressure valve, symbols. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, speed control of cylinders – supply air throttling and Exhaust air throttling and Exhaust air throttling.

Signal Processing Elements: Use of Logic gates-OR and AND gates in pneumatic applications. Practical Examples involving the use of logic gates, Pressure dependant controls-types-construction-practical

applications, Time dependent controls principle. Construction, practical applications

Electro-Pneumatic Control: Principles-signal input and output, pilot assisted solenoid control of directional control valves, Use of relay and contactors. Control circuitry for simple signal cylinder application.

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

1. CO1: Apply the concepts of hydraulic systems.
2. CO2: Design and analyze the hydraulic circuits.
3. CO3: Familiarize the student in the area of Pneumatic systems, Signal Processing and Controls.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	**Fluid Power with Applications**	Anthony Esposito	Pearson Education, Inc	Sixthedition,2000
2	**Pneumatics and Hydraulics**	Andrew Parr	Jaico Publishing Co	
Reference Books				
1	**Oil Hydraulic systems**	S. R. Majurr	Tata McGraw Hill Publishing Company Ltd	2001
2	**Industrial Hydraulics**	Pippenger, Hicks	Mc Graw Hill, NewYork	
3	**Hydraulic &Pneumatic Power for Production**	Harry L. Stewart		
4	**Pneumatic Systems**	S. R. Majumdar	Tata McGraw Hill Publish	1995
5	**Power Hydraulics**	Michael J Pinches & John G Ashby	Prentice Hall	

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VII

HEAT & MASS TRANSFER
Professional Elective - 2

Course Code	**18AE734/18AS734**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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. Heat transfer problems in turbine and nozzle blades.

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

1. CO1: Describe the fundamental of heat and mass transfer.
2. CO2: Familiarize the student in the area of conduction, convection and radiation.
3. CO3: Analyze the problems due to heat transfer in several areas.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Heat transfer-A basic approach	Ozisik	Tata McGraw Hill	2002
2	Heat Transfer	Holman, J.P	McGraw Hill Book Co., Inc., New York	8th edition,1996
Reference Books				
1	Fundamentals of Engineering Heat and Mass Transfer	Sachdeva, S.C	Wiley Eastern Ltd., New Delhi	1981
2	Rocket Propulsion Elements	Sutton, G.P	John Wiley and Sons	5th Edn.1986
3	Gas Turbine and Jet and Rocket Propulsion	Mathur, M.and Sharma, R.P	Standard Publishers, New Delhi	1988
4	Heat transfer	P.K. Nag	Tata McGraw Hill	2002
5	Heat transfer, a practical approach	Yunus A-Cengel	Tata McGraw Hill	3rd edition, 2007

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SEMESTER – VII

HIGH PERFORMANCE COMPUNTING

Course Code	**18AE741/18AS741**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the concepts of high performance computing
- Acquire the knowledge of various algorithms required for parallel computing.
- Understand the concepts of architecture.

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)

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.

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.

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).

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.

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

1. CO1: Apply the concepts of high performance computing
2. CO2: Develop various algorithms required for parallel computing.
3. CO3: Compare architectures for high performance computing.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				

1	An Introduction to Parallel Computing, Design and Analysis of Algorithms	Grama, A. Gupta, G. Karypis, V. Kumar	Pearson Education India	2nd edition, 2004
2	Parallel Scientific Computing in C++ and MPI: A Seamless Approach to Parallel Algorithms and their Implementation	G.E. Karniadakis, R.M. Kirby II	Cambridge University Press	2003
Reference Books				
1	Parallel Programming: Techniques and Applications Using Networked Workstations and Parallel Computers	Wilkinson and M. Allen	Pearson	2nd edition, 2006
2	Parallel Programming in C with MPI and Open MP	M.J. Quinn	McGraw-Hill	1st edition,2003
3	Highly Parallel Computing	G.S. Almasi and A. Gottlieb	Addison-Wesley	1994
4	The Sourcebook of Parallel Computing	J. Dongarra, I. Foster, G. Fox, W. Gropp, K. Kennedy, L. Torczon	Morgan Kaufmann	2002

B.E AERONAUTICAL ENGINEERING
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SEMESTER – VII
Professional Elective - 3

WIND TUNNEL TECHNIQUES

Course Code	**18AE742/18AS742**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic of wind tunnel testing.
- Understand the types and functions of wind tunnel.
- Acquire the knowledge on conventional measurement techniques and special wind tunnel techniques.

Module-1

Principles Of Model Testing: Buckingham Theorem, Non dimensional numbers, Scale effect, Geometric Kinematic and Dynamic similarities.

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.

Module-2

Calibration Of Wind Tunnels: Test section speed, Horizontal buoyancy, Flow angularities, Flow uniformity & turbulence measurements, Associated instrumentation, Calibration of subsonic & supersonic tunnels.

Module-3

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.

Module-4

Special Wind Tunnel Techniques: Intake tests, store carriage and separation tests, Unsteady force and pressure measurements, Non-Intrusive Flow Diagnostics, Laser – Doppler Anemometry. Particle Image Velocimetry. Laser Induced Fluorescence

Module-5

Fundamentals of wind tunnel design – introduction, general considerations, general design procedure, main design criteria, wind tunnel component specification, design of various components of wind tunnel - test chamber, contraction, settling chamber, diffuser, power plant, turning vane, fan and drive system, safety net design

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

1. CO1: Apply the principles and procedures for model testing in the wind tunnel.
2. CO2: Classify the types and functions of wind tunnel.
3. CO3: Distinguish the conventional measurement techniques and special wind tunnel techniques.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year

Textbook/s				
1	Low Speed Wind Tunnel Testing	Rae, W.H. and Pope, A.	John Wiley Publication	3rd edition, 2010
2	High Speed Wind Tunnel Testing	Pope, A., and Goin, L	John Wiley	1985
Reference Books				
1	Instrumentation, Measurements, and Experiments in Fluids	E. Rathakrishnan	CRC Press	2007
2	Experimental Fluid Mechanics	Bradsaw	Pergamon Press	2nd Revised edition,1970
3	Wind Tunnel Designs and their Diverse Engineering Applications	Noor Ahmed		2013
4	Advanced Flow diagnostic techniques			
5	Experimental Aerodynamics			

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SEMESTER –VII

GUIDANCE, NAVIGATION & CONTROL

Course Code	**18AE743/18AS743**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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).

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.

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.

Module-4

Missile Guidance
Proportional navigation guidance; command guidance. Comparison of guidance system performance. Bank to turn missile guidance

Module-5

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

1. CO1: Apply the basic concepts of navigation, guidance and control.
2. CO2: Compare the different types of missile guidance system performance.
3. CO3: Integrate the flight and fire control system.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fundamentals of Aerospace Navigation and Guidance	P.T. Kabamba and A.R. Girard	Cambridge Aerospace Series	2014
2	Automatic control of Aircraft & Missiles	John H Blakelock	Wile –Inter SciencePublication	2nd edition, May 1990
Reference Books				
1	Navigation	R.B. Underdown& Tony Palmer	Black Well Publishing	2001
2	Introduction to Radar Systems	Merrilh I. Skolnik	Tata Mc Graw Hill	3rd edition,2001
3	Missile Guidance and Control Systems	George M. Siouris	Springer	2004

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SEMESTER –VII
Professional Elective - 3

OPERATIONS RESEARCH

Course Code	**18AE744**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Understand the basic of operations research.
- Comprehend the PERT-CPM techniques, queuing theory and game theory.
- Acquire the knowledge on sequencing.

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.

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 sales man problem.

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.

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.

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 2 jobs on 'm' machines using graphical method.

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

1. CO1: Apply the basic of operations research.
2. CO2: Classify the PERT-CPM techniques, queuing theory and game theory.
3. CO3: Identify the sequencing techniques.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Operations Research	P K Gupta and D S Hira	Chand Publications, New Delhi	Revised edition, 2007
2	Operations Research	Taha H A	Pearson Education	9th edition,2014
Reference Books				
1	Operations Research	A P Verma	S K Kataria & Sons	2012
2	Operations Research	Paneerselvan	PHI	2nd edition,2009
3	Operations Research	A M Natarajan, P Balasubramani	Pearson Education	1st edition,2011
4	Introduction to Operations Research	Hillier and Liberman	Mc Graw Hill	8thEd
5	Operations Research	S. D. Sharma	Kedarnath Ramanath & Co	2012

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SEMESTER - VII

MODELING & ANALYSIS LAB

Course Code	**18AEL76**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- 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.

Sl. No.	Experiments
1	Modeling of Symmetrical/Cambered Aerofoil Geometry , and Generation of Body Fitting Adaptive Mesh.
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.
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.
4	Isentropic Flow Analysis in a 2-D Subsonic Diffuser and a Subsonic Nozzle.
5	Isentropic Flow Analysis in a 2-D Supersonic Diffuser and a Supersonic Nozzle.
6	Geometric Modeling and Mesh Generation of a 2-D Convergent-Divergent Nozzle and Analyses of flow for Adiabatic Conditions (Fanno Flow).
7	Geometric Modeling and Mesh Generation of a 2-D Pipe and Modeling of Steady/Unsteady Heat Convection and Conduction (Rayleigh Flow).
8	Structural Modeling of Sandwich Beam of Rectangular Cross-section and Analyses for Stress for
9	Structural Modeling and Stress Analysis of a Torsion Box of a Wing.
10	Structural Modeling and Stress Analysis of a Fuselage Frame.
11	Structural Modeling and Stress Analysis of a Tapered I-Section Spar.
12	Determine the Natural frequency and Mode shapes of a Cantilever beam under UDL.
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.
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.

Course Outcomes: At the end of the course the student 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. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

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SEMESTER - VII

FLIGHT SIMULATION LAB

Course Code	**18AEL77**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(1:0:2)	SEE Marks	60
Credits	02	Exam Hours	03

Course Learning Objectives:

- 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.

Sl. No.	Experiments
1	Draw Pole-Zero map of dynamic system model with plot customization option
2	Plot root locus with variables in transfer function through MATLAB
3	Plot root locus for a dynamic system though MATLAB
4	Draw Bode plot from a transfer function in MATLAB and explain the gain and phase margins
5	Simulate a spring- mass- damper system with and without a forcing function though SIMULINK
6	Simulate a simple servo-mechanism motion with feedback- in the time domain, and in `s` domain
7	Simulate a bomb drop from an aircraft on a moving tank in pure pursuit motion
8	Develop a straight and level flight simulation program using MATLAB
9	Simulate aircraft Take-off and Landing with trajectory tracing
10	Simulate stall of aircraft and show the effect of variation in static margin on stalling characteristics
11	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.
12	Simulate aircraft longitudinal motion and demonstrate the effect of static margin variation for a doublet input in pitch.
13	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.
14	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.

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

1. CO1: Plot the root locus and bode plot.
2. CO2: Calculate the dynamics response of aircraft.
3. CO3: Use computational tools to model aircraft trajectory.

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

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SEMESTER –VII
Open Elective - B

MAINTENANCE, OVERHAUL & REPAIR OF AIRCRAFT SYSTEMS

Course Code	**18AE751/18AS751**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

Module-1

Fundamentals of Maintenance & Certification

Types of maintenance, Redesign, Failure rate pattern, Other 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).

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

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.

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.

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

1. CO1: Maintain the aircraft maintenance manual and logbook.
2. CO2: Do the quality control and calibration.
3. CO3: Incorporate the safety regulations and rules.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aviation Maintenance Management	Harry A Kinnison, Tariq Siddiqui	Mc Graw Hill education (India) Private Ltd	2013
2	Aircraft maintenance and repair	Kroes, Watkins, Delp	Mc Graw Hill	2013
Reference Books				
1	Aircraft Repair Manual	Larry Reithmaier	Palmar Books, Marquette	1992
2	Aircraft Maintenance	Brimm. DJ, Bogges, HE	Pitman publishing corp, London	1952

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SEMESTER - VII

FUNDAMENTALS OF AERODYNAMIC THEORY

Course Code	**18AE752/18AS752**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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.

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

1. CO1 :Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
2. CO2 :Compute and analyse the incompressible flow over finite wings

3. CO3 : Apply finite wing theory and design high lift systems from the aerodynamics view point

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Fundamental of Aerodynamics	Anderson J.D	McGraw-Hill International Edition, New York	5th edition,2011
2	Aerodynamics for Engineering Students	E. L. Houghton, P.W. Carpenter	Elsevier, New York	5th edition,2010
Reference Books				
1	Aerodynamics	Clancy L. J.	Sterling book house, New Delhi	2006
2	Theoretical Aerodynamics	Louis M. Milne-Thomson	Dover Publications, USA	Imported Edition,2011

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VII
Open Elective - B

UNMANNED AERIAL VEHICLES

Course Code	**18AE753/18AS753**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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

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.

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.

Module-4

Propulsion
Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, and Sources of Electrical Power.
Loads and Structures
Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques.

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

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

1. CO1: Apply the basic concepts of UAV systems.
2. CO2: Explain the basic aerodynamics, performance, stability and control required for UAV.
3. CO3: Select the propulsion system and materials for structures.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Introduction to UAV Systems	Paul Gerin Fahlstrom, Thomas James Gleason	Wiley Publication	4th Edition,2012
2	Unmanned Aerial Vehicle	Landen Rosen	Alpha Editions	
Reference Books				
1	Unmanned Aerial Vehicles: DOD's Acquisition Efforts		Alpha Editions	
2	Unmanned Aerial Vehicles	Valavanis, Kimon P	Springer	2011
	Handbook of Unmanned Aerial Vehicles	Valavanis**,** K.,Vachtsevanos, George J	Springer	2015

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII

FLIGHT VEHICLE DESIGN

Course Code	**18AE81**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

Module-4

Static Stability & Control

Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe 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.

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

1. CO1: Calculate the thrust to weight ratio and wing loading.
2. CO2: Compute the flight vehicle performance.
3. CO3: Select the subsystems as per vehicle design.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Aircraft Design - A Conceptual Approach	Daniel P. Raymer	AIAA Education Series	IV Edition, 2006
2	Design of Aircraft	Thomas C Corke	Pearson Edition. Inc.	2003
Reference Books				
1	Aeroplane Design	J Roskam		
2	Introduction to Aircraft Design	John Fielding	Cambridge University Press	2009
3	Standard Handbook for Aeronautical & Astronautical Engineers	Editor Mark Davies	Tata McGraw Hill	2010

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER - VIII

AVIONICS

Course Code	**18AE821**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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 sub systems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.

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, and HOTAS.

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–STD1553B.

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

1. CO1: Select the suitable data bus based on the application.
2. CO2: Identify the suitable navigation systems.
3. CO3: Distinguish the avionics system architecture.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year

Textbook/s

1	Introduction to Avionics Systems	R.P.G. Collinson	Springer	3rd edition, 2011
2	Aircraft Systems: Mechanics, Electrical and Avionics Subsystems Integration	Ian Moir, Allan Seabridge	Wiley	3rd Edition, 2012
Reference Books				
1	Avionics Systems, Longman Scientific and Technical	Middleton, D.H., Ed	Longman Group UK Ltd., England	1989
2	Digital Avionic Systems	Spitzer, C. R	McGraw-Hill Inc., US	2nd edition, 1992
3	Aircraft Communications and Navigation Systems	Mike Tooley and David Wyatt	Butterworth Heinemann	2007
4	Introduction to Avionics	D.R. Cundy and R.S. Brown	Pearson	2010

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VIII
Professional Elective - 4

BOUNDARY LAYER THEORY

Course Code	**18AE822**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

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

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.

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.

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.

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.

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.

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

1. CO1: Apply the basic concepts and equations of viscous flow.
2. CO2: Discuss the importance of Navier Stokes equation.
3. CO3: Measure the turbulence.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Boundary Layer Theory	H. Schlichting	McGraw- Hill, New York	1979
2	Viscous Fluid flow	Frank White	McGraw Hill	1991
Reference Books				
1	Experimental methods for Engineers	J.P. Hollman and W.J. Gajda, Jr	McGraw- Hill	5th Edition,1989
2	Incompressible fluid flow	Ronald L., Panton	John Wiley & Sons	1984

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER – VIII
Professional Elective - 4

HELICOPTER DYNAMICS

Course Code	**18AE823**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

1. CO1: Comprehend the basic concepts of helicopter dynamics.
2. CO2: Acquire the knowledge of critical speed and rotor bearing system.
3. CO3: Understand the turborotor system and blade vibration.

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 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.

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.

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.

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.

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

1. CO1: Apply the basic concepts of helicopter dynamics.
2. CO2: Compute the critical speed by using various methods.
3. CO3: Distinguish the turborotor system stability by using transfer matrix and finite element formulation.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Principles of Helicopter Aerodynamics	J. Gordon Leishman	Cambridge University Press	2002
2	Dynamics of Helicopter Flight	George H. Saunders	John Wiley & Sons, Inc, NY	1975
Reference Books				
1	Rotary Wing Aerodynamics	W Z Stepniewski and C N Keys	Dover Publications,Inc, New York.	1984
2	Helicopter Dynamics	ARS Bramwell, George Done, and David Balmford	Butterworth-Heinemann Publication	2nd Edition,2001
3	Basic Helicopter Aerodynamics	John, M. Seddon and Simon Newman	Wiley	2011
4	Helicopter Flight Dynamics	Gareth D. Padfield	Wiley	2nd Edition,2011

B.E AERONAUTICAL ENGINEERING
Choice Based Credit System (CBCS) and Outcome Based Education (OBE)
SEMESTER –VIII

FLIGHT TESTING

Course Code	**18AE824**	CIE Marks	40
Teaching Hours/Week (L:T:P)	(3:0:0)	SEE Marks	60
Credits	03	Exam Hours	03

Course Learning Objectives:

- Comprehend the basic concepts of flight test instrumentation.
- Acquire the knowledge of performance flight testing and stability control.
- Understand the flying qualities.

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.

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.

Module-3

Stability and control - longitudinal and maneuvering
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.

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.

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

1. CO1: Measure the flight parameters.
2. CO2: Estimate the performance of flight.
3. CO3: Apply the FAR regulations.

Question paper pattern:

- The question paper will have ten full questions carrying equal marks.
- Each full question will be for 20 marks.
- There will be two full questions (with a maximum of four sub- questions) from each module.
- Each full question will have sub- question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Sl. No.	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Textbook/s				
1	Flight Testing of Fixed Wing Aircraft	Ralph D Kimberlin	AIAA educational Series	2003
2	Flight Testing- Conventional and Jet Propelled Airplanes	Benson Hamlin	Mac Millan	1946
Reference Books				
1	Flight Test Manual	AGARD		
2	Small Unmanned fixed-wing Aircraft Design	A.J. Keane, A. Sobester	Wiley	2017
3	Flight Performance of Fixed and Rotary Wing Aircraft	A. Filippone	AIAA Series	2006