DAYANANDA SAGAR UNIVERSITY

SHAVIGE MALLESHWARA HILLS, KUMARASWAMY LAYOUT BENGALURU–560 111, KARNATAKA.

SCHOOL OF ENGINEERING

SCHEME &
SYLLABUS FOR
BACHELOR OF TECHNOLOGY
(B.Tech) IN

AEROSPACE ENGINEERING
2018-2022

16AS XXXX

SCHEME OF B.TECH IN AEROSPACE

ENGINEERING III SEM

SL	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
				L	T	P	S/P	C	CIA	END EXAM
1	16MA201	ENGINEERING MATHEMATICS – III	CR	04	--	--	--	04	40	60
2	16AS202	INTRODUCTION TO AEROSPACE ENGINEERING	CR	03	--	--	--	03	40	60
3	16AS203	THERMODYNAMICS	CR	03	01	--	--	04	40	60
4	16AS204	FLUID MECHANICS	CR	03	01	--	--	04	40	60
5	16AS205	SOLID MECHANICS	CR	03	01	--	--	04	40	60
6	16AS206	AEROSPACE MATERIALS	CR	03	--	--	--	03	40	60
7	16AS271	COMPOSITES LAB	CR	--	--	03	--	1.5	40	60
8	16AS272	FLUID MECHANICS LAB	CR	--	--	03	--	1.5	40	60
9	16AS281	MINI PROJECT – I	CR	--	--	--	04	02	40	60
GRAND TOTAL = 900				**19**	**03**	**06**	**04**	**27**	**360**	**540**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,
CIA – Continuous Internal Assessment

SCHEME OF B.TECH IN AEROSPACE

ENGINEERING IV SEM

SL	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
				L	T	P	S/P	C	CIA	END EXAM
1	16MA202	ENGINEERING MATHEMATICS – IV	CR	04	--	--	--	04	40	60
2	16AS207	AERODYNAMICS – I	CR	03	01	--	--	04	40	60
3	16AS208	AEROSPACE STRUCTURAL MECHANICS	CR	03	01	--	--	04	40	60
4	16AS209	MECHANISMS AND MACHINE THEORY	CR	03	01	--	--	04	40	60
5	16AS210	AIRCRAFT PROPULSION	CR	03	--	--	--	03	40	60
6	16AS211	PRODUCT DESIGN - 1	CR	02	--	02	--	03	40	60
7	16AS273	AEROSPACE STRUCTURES LAB	CR	--	--	03	--	1.5	40	60
8	16AS274	MATERIAL TESTING LAB	CR	--	--	03	--	1.5	40	60
9	16AS282	MINI PROJECT – II	CR	--	--	--	04	02	40	60
GRAND TOTAL = 900				**18**	**03**	**08**	**04**	**27**	**360**	**540**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,
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SCHEME OF B.TECH IN AEROSPACE

ENGINEERING V SEM

SL	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
				L	T	P	S/P	C	CIA	END EXAM
1	16AS301	AERODYNAMICS-II	CR	03	01	--	--	04	40	60
2	16AS302	INTRODUCTION TO SPACE TECHNOLOGY	CR	04	--	--	--	04	40	60
3	16AS303	AIRCRAFT PERFORMANCE	CR	03	01	--	--	04	40	60
4	16AS304	PRINCIPLES OF MANAGEMENT AND ECONOMICS FOR ENGINEERS	CR	03	--	--	--	03	40	60
5	16AS3XX	PROGRAM ELECTIVE – 1	CR	03	--	--	--	03	40	60
6	16IE3XX	OPEN ELECTIVE – 1	CR	03	--	--	--	03	40	60
7	16AS371	AEROSPACE PROPULSION LAB	CR	--	--	03	--	1.5	40	60

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

PROGRAM ELECTIVE – I

SL	COURSE CODE	COURSE TITLE
1	16AS311	WIND TUNNEL MODEL TESTING
2	16AS312	AIR TRANSPORTATION SYSYEM
3	16AS3132	FINITE ELEMENTAL METHODS

SCHEME OF B.TECH IN AEROSPACE

ENGINEERING VI SEM

SL	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING					SCHEME OF EVALUATION	
				L	T	P	S/P	C	CIA	END EXAM
1	16AS305	CONTROL THEORY	CR	03	01	--	--	04	40	60
2	16AS306	AIRCRAFT SYSTEMS AND INSTRUMENTATION	CR	03	--	--	--	03	40	60
3	16AS307	AIRCRAFT STABILITY AND CONTROL	CR	03	--	--	--	03	40	60
4	16AS308	ORBITAL MECHANICS	CR	03	--	--	--	03	40	60
5	16AS3XX	PROGRAM ELECTIVE – 2	CR	03	--	--	--	03	40	60
6	16IE3XX	OPEN ELECTIVE – 2	CR	03	--	--	--	03	40	60
7	16AS373	SIMULATION LAB	CR	--	--	03	--	1.5	40	60

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,
CIA – Continuous Internal Assessment

PROGRAM ELECTIVE – 2

SL	COURSE CODE	COURSE TITLE
1	16AS314	INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS
2	16AS315	MANUFACTURING TECHNOLOGY

VII SEMESTER

SL	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING						SCHEME OF EVALUATION	
				L	T	P	S/P	C	No. of hour/ Week	CIA	END EXAM
1	16AS401	Avionics	CR	3			2	4	4	40	60
2	16AS404/16AS406	Program Elective 3	CR	3				3	3	40	60
3	16AS408/16AS410	Program Elective 4	CR	3				3	3	40	60
4	16IEXXX	Open Elective -3	CR	3				3	3	40	60
5	16AS402	Law for Engineers	CR	3				3	3	40	60
7	16AS471	AI&ML Lab	CR			4		2	4	40	60
8	16AS472	Major Project Stage-1	CR				10	5	10	40	60
TOTAL				**15**		**4**	**11**	**23**	**30**	**280**	**420**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits, CIA – Continuous Internal Assessment

PROGRAM ELECTIVE – 3

SL	COURSE CODE	COURSE TITLE
1	16AS403	Helicopter Dynamics
2	16AS406	Aircraft Design
3	16AS404	Unmanned Aircraft Systems & E-Mobility

PROGRAM ELECTIVE – 4

SL	COURSE CODE	COURSE TITLE
1	16AS407	Optimization Techniques
2	16AS408	Satellite Technologies
3	16AS409	Introduction to Artificial Intelligence and Machine Learning
4	16AS410	Aircraft Maintenance, Overhaul and Repair

VIII SEMESTER

SL	COURSE CODE	COURSE TITLE	CR / AU	SCHEME OF TEACHING						SCHEME OF EVALUATION	
				L	T	P	S/P	C	No. of hour/Week	CIA	END EXAM
1	16AS411	Program Elective – 5	CR	03	--	--	--	03	03	40	60
2	16AS4XX	Open Elective – 4	CR	03	--	--	--	03	03	40	60
3	16AS481	Major Project Stage – II	CR	--	--	--	18	09	18	100	100
4			**TOTAL**	**06**	**--**	**--**	**06**	**15**	**24**	**180**	**220**

CR – Credit, AU – Audit, L – Lecture, T – Tutorial, P – Practical, S/P – Seminar/Project, C – No. of Credits,
CIA – Continuous Internal Assessment

SL	COURSE CODE	COURSE TITLE
1	16AS412	Aerospace Technical Publications
2	16AS413	Rockets and Missiles
3	16AS414	NPTEL Course on Rocket Propulsion

SL	COURSE CODE	COURSE TITLE
1	16IE470	Aircraft Systems and Instrumentation

NPTEL Course on Rocket Propulsion can be completed from any open online courses (SWAYAM/NPTEL/COURSERA/MOOC etc.). A list of 5-7 courses will be suggested by the department. Students need to select one from this list .

SEMESTER/YEAR : III SEM / II
YEAR COURSE CODE : 16MA201
TITLE OF THE COURSE : ENGINEERING MATHEMATICS – III
L: T: P: S/P : C : 04 :00 : 00 :00 : 04

Course objectives

- Understand linear system of equations
- Understand the structure of Matrices and Determinants
- Infer different co-ordinate systems and applications of vectors.
- Know the higher integrations applications in polar coordinates.
- Learn the concepts of Surface areas and apply to solve numerical problems in engineering domain.

Course outcomes

- Apply Linear Algebra to solve linear equations for a given linear system.
- Evaluate numerical problems on matrices and determinants.
- Analyze vectors in space and solve problems in engineering domain.
- Apply double and triple integrations to solve engineering problems.
- Apply Line integration concepts to vectors in space for problems.
- Calculate surface areas of given distribution functions.

LINEAR EQUATIONS

Linear transformations, Matrix of Linear Transformations, Matrix Operations, Row reduction and echelon forms, Inverse of a matrix, Systems of linear equations, Vector equations, Solution sets of linear equations, Properties of invertible matrices.

MATRICES & DETERMINANTS

Determinants, Eigenvalues and Eigenvectors, Characteristic equation, Diagonalization, Diagonalization of symmetric matrices, Quadratic forms and Singular Value Decomposition

3-D GEOMETRY

3-D Coordinate systems, Vectors, Dot and Cross products, Lines, planes and curves in space, Tangents to curves, Normal vectors of curve, Taylor's formula for two variables.

MULTIPLE INTEGRALS

Double integration in polar form, Triple integration in cylindrical and spherical coordinates, Line integrals, Vector Fields and Line integral

GREEN'S, STOKE'S AND DIVERGENCE THEOREMS

Path independence, Green's theorem, Surfaces and area, Surface Integrals, Stoke's Theorem, Divergence Theorem

Text Books:

1. Linear Algebra and its applications, David Lay, Steven Lay, Judi Mc Donald, Pearson , 5th edition
2. Thomas's Calculus, G.B.Thomas, M.Weir, J. Hass, Pearson , 12th edition

Reference Books:

1. Advanced Engineering Mathematics, E. Kreyzsig, Wiley, 10th Edition
2. Introduction to Linear Algebra, G. Strang, Wellesely- Cambridge Press, 4th edition.

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS202
TITLE OF THE COURSE : INTRODUCTION TO AEROSPACE ENGINEERING
L: T/A:P: C : 03:00:00:00:03

COURSE LEARNING OBJECTIVES:

This course will enable students to:

- Understand basic principles of aviation and the history of space vehicles
- Acquire the basic knowledge of aircraft structures, aerodynamics, propulsion, materials, aircraft systems & instrumentation
- Understand the basics of spacecraft and orbital mechanics

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Apply the basic knowledge & principles of aerospace vehicles and spacecraft
- Apply the concepts of fundaments of flight, basics of aircraft structures, aircraft & rocket propulsion and aircraft materials during the development of an aircraft
- Understand the complexities involved during development of aerospace vehicles

Module -1: INTRODUCTION TO AEROSPACE ENGINEERING: **9L Hrs**

History of aviation, Atmosphere, space and its properties, Classification of aircraft and space vehicle, Aircraft Nomenclature, Modern developments in Aviation.

Introduction to Space Flight: History of Space Flight & spacecraft technologies, Introduction to basic orbital mechanics, Kepler's Laws of planetary motion. Types of Orbits.

Module -2: FUNDAMENTALS OF AERODYNAMICS: 9L Hrs

Aerodynamic forces and moments on an Airfoil, Lift and drag components, lift curve, drag curve, types of drag, factors affecting lift and drag, Centre of pressure and its significance, Aerodynamic center, Aspect ratio, Airfoil nomenclature, Basic characteristics of airfoils, Simple problems on lift and drag. Significance of speed of sound, Propagation of sound, Mach number, subsonic, transonic, supersonic, hypersonic flows.

Module -3: AIRCRAFT PROPULSION 9LHrs

Introduction, Classification, Piston Engine & its application, Brayton cycle, Principle of operation of Turboprop, turbojet and turbofan engines, Introduction to ramjets and scramjets; performance characteristics

Rocket Propulsion: Principles of operation of rocket, Classification of Rockets, Types of rockets and typical applications, Introduction to Space Exploration.

Module -4: AIRCRAFT STRUCTURES **8L Hrs**

Introduction, General types of construction, Truss, Monocoque, Semi-Monocoque and Geodesic structures, typical wing and fuselage structure. Introduction to Aircraft Materials.

Module -5: AIRCRAFT INSTRUMENTS **9L Hrs**

Instrument Displays, Introduction to Navigation Instruments, Basic Air data systems & Probes, Mach meter, Air speed indicator, Vertical speed indicator, Altimeter, Gyro based instruments. **Aircraft Systems :** Introduction to Hydraulic and pneumatic systems, Air Conditioning and Cockpit pressurization system, Generation and distribution of Electricity on board the airplane, Aircraft Fuel System, Fire Protection, Ice and Rain Protection System.

Text Books:

1. John D. Anderson, "Introduction to Flight", McGraw-Hill Education, 8th edition, 2015, ISBN: 978-0078027673.
2. Lalit Gupta and O P Sharma, Fundamentals of Flight Vol-I to Vol-IV, Himalayan Books. 2006, ISBN: 9788170020752

Reference Books:

1. Ian Moir, Allan Sea bridge, "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", John Wiley & Sons, 3rd edition, 2011, ISBN: 9781119965206.
2. Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition, 2016, ISBN: 9781118753910.
3. A.C. Kermode, "Flight without formulae", Pearson Education India, 5th edition, 1989, ISBN: 9788131713891.
4. Nelson R.C., "Flight stability and automatic control", McGraw-Hill, 2nd edition, 1998, ISBN: 9780071158381.
5. T.H.G Megson "Introduction to Aircraft Structural Analysis", Elsevier Exclusive Publications, 2nd edition, 2014, ISBN 13: 978-9351071860.

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS203
TITLE OF THE COURSE : THERMODYNAMICS
L: T/A: P: C : 03: 01: 00: 00:04

COURSE LEARNING OBJECTIVES:

This course will enable students to:

Understand the basic concepts of thermodynamics

- Understand the thermodynamics laws
- Develop an understanding of working principles of gas power cycles
- Understand the working principles aircraft propulsion systems

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Apply the concepts of thermodynamics to different processes
- Analyse the various gas power cycles
- Analyse different aero engine cycles and propulsion systems

Module -1: BASIC CONCEPTS OF THERMODYNAMICS 8L+2T Hrs

Introduction- Basic Concepts: System, Control Volume, Surrounding, Boundaries, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, Thermodynamic properties: definition and units. Intensive and extensive properties. Thermodynamic state, state point, path and process, quasi-static process, cyclic and non-cyclic processes, Energy and its forms, Work and heat (sign convention), irreversible process, causes of irreversibility

Module -2: ZEROTH LAW AND FIRST LAW THERMODYNAMICS 10 L+2T Hrs

Zeroth law of thermodynamics statement, Concept of Temperature and its' measurement, Temperature scales.

First Law of Thermodynamics: First law of thermodynamics-application to closed and open system, Joules experiments, equivalence of heat and work, Internal energy and enthalpy, energy as a property, steady state, Steady Flow Energy Equation, extension of first law to control volume, Application of SFEE, Limitations of first law of thermodynamics

Module -3: SECOND LAW OF THERMODYNAMICS AND PURE SUBSTANCE 2L+2T Hrs

Thermal reservoirs, Efficiency, devices converting work to heat in a thermodynamic cycle, direct heat engine, reversed heat engine, Refrigerator and Heat Pump, Coefficient of Performance, Kelvin-Planck and Clausius statement of second law of thermodynamics, Equivalence of the two statements, reversible and irreversible processes, , Carnot theorem and its corollaries.Second law, entropy and absolute temperature, third law and absolute entropy, Introduction to energy.

PURE SUBSTANCE: P-T and P-V diagrams, triple point and critical points. Sub-cooled liquid, saturated liquid, mixture of saturated liquid and vapor, saturated vapor and superheated vapor states of pure substance with water as example. Enthalpy of change of phase (Latent heat), Dryness fraction (quality), T-S and H-S diagrams.

Module -4: THERMODYNAMIC GAS & VAPOUR CYCLES 10L+2T Hrs

Otto cycle, Diesel cycle, dual cycle, Rankine cycle, Joule-Brayton cycle, ideal and real cycles. Numerical problems

Module -5: INTRODUCTION HEAT TRANSFER 10L+2THrs

Thermodynamics and Heat Transfer, Applications, Historical background, Heat transfer modes, Conduction, Fourier law, Thermal conductivity, diffusivity, Convection; Newton's law of cooling, Radiation heat transfer, Simultaneous heat transfer mechanisms, Overall heat transfer coefficient.

Text Books:

1. Sonntag, R. E., Borgnakke ,C. and Van Wylen , G. J., "Fundamentals of Thermodynamics", 6th ed., Wiley, 2002
2. Cengel, Y., and Boles, M., "Thermodynamics: an Engineering Approach", 7th Ed., McGraw Hill, 2010
3. Rogers and Mayhew, "Engineering Thermodynamics: Work and Heat Transfer", 4th Ed, Longman Scientific, 1992.

Reference Books:

1. Nag, P. K., "Engineering Thermodynamics", 4th ed., Tata McGraw Hill, 2008
2. Sutton G.P., "Rocket Propulsion Elements", John Wiley, New York, 9th edition, 2016, ISBN: 9781118753910.
3. Cengel, Y., and Ghajar, "Heat transfer: A practical approach", McGraw Hill, 2nd Ed., 2002
4. Hill, P., and Peterson, C., "Mechanics and Thermodynamics of Propulsion", Pearson Education, 2009
5. Farokhi, Saeed, "Aircraft Propulsion", Wiley-Blackwell 2nd Ed., 2014.

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS204
TITLE OF THE COURSE : FLUID MECHANICS
L: T/A: P: C : 03:01:00:00:04

COURSE LEARNING OBJECTIVES:

This course will enable students to:

- Understand the basics of incompressible fluid properties and flow regimes
- Study different types of fluid flows and governing laws
- Understand the concept of boundary layer theory

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Solve problems on incompressible fluid flow
- Analyse different flow regimes using governing laws of fluid flow
- Apply the concept of boundary layer in fluid flow
- Apply the principles of dimensional analysis for incompressible flow

Module -1: FLUID PROPERTIES AND FLUID STATICS 10L Hrs

Introduction, properties of fluids, viscosity, thermodynamics properties, surface tension and capillarity, vapor pressure. Fluid pressure at a point, Pascal's law, pressure variation in a static fluid, absolute, gauge, atmospheric and vacuum pressures, simple manometers and differential manometers. Hydrostatic forces on plane, inclined and curved surfaces, Fluid Statics: Fluid pressure at a point, Pascal's law, pressure variation in a static fluid. Total pressure and center of pressure on submerged plane surfaces, horizontal, vertical and inclined plane surfaces, curved surface submerged in liquid.

Module -2: FLUID KINEMATICS 8L + 3T Hrs

Lagrangian and Eulerian descriptions,Types of flows; Steady flow, Unsteady flow, Uniform and Non-Uniform flow, Rotational flow, Irrational flow, 1-D, 2-D, 3-D flows, Continuity equation, velocity and acceleration, velocity potential function, Stream function, lines of constant stream function and equipotential line, Streamline, Pathline, and Streakline, Dilatation strain rate, Circulation, Vorticity.

Module -3: FLUID DYNAMICS AND FLOW MEASUREMENT 10L + 3T Hrs

Introduction, Euler's Equation of motion, Assumptions, Bernoulli's equation, Bernoulli's equation for real fluids and application, Measurement of flow, venturimeter, orifice meter, pitot tube.

Module -4: DIMENSIONAL ANALYSIS 8L + 3T Hrs

Introduction, Dimensional homogeneity – Raleigh and Buckingham theorems – Non dimensional numbers – Model laws and distorted Models-Unit Quantities-Specific Quantities.

Module -5: BOUNDARY LAYER THEORY **12L + 3T Hrs**

Equation of motion in differential form, Viscous flow, exact solutions, pipe flow. Laminar boundary layers. Boundary layer solution methods.Introduction to Turbulence, Reynolds averaging, Reynolds stress, Mixing length model. Turbulent boundary layer.

Text Books:

1. White, F. M., "Fluid Mechanics (SI Units)", 7th Ed., Special Indian Edition, McGraw Hill, 2011.
2. Panton, R. L., "Incompressible Flow", 3rd Ed., Wiley India Edition, 2006.
3. Cengel, Y. A., Cimbala, J. M., "Fluid Mechanics (Fundamentals and Applications)", 2nd Ed., Tata McGraw Hill, 2010.

Reference Books:

1. Dr. R.K. Bansal, (2000), "Fluid Mechanics and Hydraulic Machines", LaxmiPublication (P) Ltd., New Delhi.
2. P.N. Modi and S.M. Seth (1999), "Hydraulics and Fluid Mechanics including Hydraulic Machines", Standard Book House, Naisarak, Delhi

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS205
TITLE OF THE COURSE : SOLID MECHANICS
L: T/A: P: C : 03: 01: 00:00:04

Course Learning Objectives:

This course will enable students to:

- Understand the basic concepts of strength of materials
- Understand stress, strain under different loading
- Study the stresses in riveted joints
- Understand the ASTM standard

Course Outcomes:

Upon successful completion of this course, the students:

- Recognize the concept of one and two dimensional simple and compound stress and strain
- Plot SF-BM diagram, slope-Deflection curve and combined stress in beams and shafts
- Solve the problems on trusses and riveted joints

Module -1: INTRODUCTION AND ELEMENTS OF 2-D & 3-D ELASTICITY 7L + 3T Hrs

Engineering Statics v/s Solid Mechanics, solid as a continuum, statement of a general solid mechanics problem.

Components of stress & strain fields, stress/strain transformation, principal stresses, plane stress/strain, Mohr's circle, equilibrium equations, strain displacement relations, compatibility conditions, natural & kinematic boundary conditions, stress-strain relations

Module -2: LINEAR ELASTICITY 7L + 3T Hrs

Generalized Hooke's Law - Isotropy, Orthotropyand Anisotropy. Displacement and force methods of analysis. Concepts of linear and nonlinear problems. Illustration of linear elasticity solutions - problems in 2-D (rectangular and polar co-ordinates), stress function approach. St. Venant's principle

Module -3: 1-D STRUCTURAL ANALYSIS 7L + 3T Hrs

Slender structural elements, assumptions simplifying the general (3-d) stress, strain and deformation fields for uncoupled axial deformation, uncoupled bending, and uncoupled twisting of slender 1-D elements and development elementary beam theory

Module -4: FORCE ANALYSIS 9L + 2T Hrs

Idealization of general loads into axial forces, bending moments, shear forces and torque distributions, deflection and stress analysis of rods, beams and circular shafts.

Module -5: STRUCTURAL DESIGN FOR STATIC AND FATIGUE LOADS 9L + 2T Hrs

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, distortion energy theory. Failure of brittle and ductile materials, stress concentration, determination of stress concentration factor. Stresses due to axial, bending and torsional loads.

Introduction, S-N Diagram, low cycle fatigue, high cycle fatigue, endurance limit, modifying factors: size effect, surface effect, stress concentration effects, fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.

Text Books:

1. Gere J M, "Mechanics of Materials", Cengage Learning, ISBN 9781337093354
2. H. Crandall, Norman C. Dahl, Thomas J. Lardner "An introduction to the Mechanics of Materials", Tata McGraw Hill Publications, ISBN 9780071070034.
3. Bansal, R.K.,"A Text Book of Strength of Materials", Lakshmi Publications Pvt. Limited, New Delhi, 2010.

Reference Books:

1. R.K.Rajput.,"Strength of materials", Fourth Edition, S. Chand Limited, 2007.
2. Beer.F.P. and Johnston.R, "Mechanics of Materials", McGraw Hill Publishers, 7th edition, 2016, ISBN-13: 978-9339217624.
3. BaoShihua, Gong Yaoqing, "Structural Mechanics" Wuhan University of Technology Press, 2005, ISBN: 7562924074 9787562924074
4. S P Timoshenko, J N Goodier, "Theory of Elasticity", Tata McGraw Hill Publications, ISBN 9870070701229
5. T.H.G Megson "Introduction to Aircraft Structural Analysis", Elsevier Exclusive Publications, 2 nd edition, 2014, ISBN 13: 978-9351071860.

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS206
TITLE OF THE COURSE : AEROSPACE MATERIALS
L: T/A: P: C : 03: 00: 00:00:03

Course learning objectives:

This course will enable students to:

- Develop an understanding of different materials used in aerospace engineering
- Understand different mechanical tests to study the strength of material
- Understand the material requirement for aircraft and space shuttle structures
- Study various metal based alloys, super alloys and high performance polymers for aerospace applications

Course Outcomes:

Upon successful completion of this course, the students:

- Demonstrate knowledge to select appropriate material for aerospace structures
- Comprehend the results of mechanical tests on materials
- Selecting the right materials for engineering process and application
- Characterize different aerospace materials of aircraft and space shuttle structures.

Module -1: INTRODUCTION TO AEROSPACE MATERIALS AND THEIR REQUIREMENTS

8L Hrs

Brief history of aerospace materials, Materials for the global aerospace industry, Types, Future advances in aerospace materials

Material requirements for aerospace structures and engines, Introduction to Fixed-wing aircraft structures, Helicopter structures, Space shuttle structures

Module -2: STRENGTH, DURABILITY AND TESTING OF AEROSPACE MATERIALS

9L Hrs

Strengthening of metal alloys: Introduction, Crystal structure of metals, Defects in crystal structures, strengthening of metal, Corrosion of aerospace metals

Introduction to Tension test, Compression test, Flexure test, Hardness test, Fracture test, Drop- weight impact test, Fatigue test, Creep test, Environmental durability testing, certification of aerospace materials, Non Destructive Testing (NDT).

Module -3: LIGHT METAL ALLOYS **9L Hrs**

Aluminium alloys for aircraft structures: Introduction, Aluminum alloy types, Heat treatment of aluminum alloys, High-temperature strength of aluminium,

Introduction to Titanium alloys and their applications, Types of titanium alloy, Titanium aluminides, Shape memory titanium alloys

Introduction to Magnesium alloys and their applications, types, Metallurgy of magnesium alloys

Module -4: COMPOSITE MATERIALS : **10 L Hrs**

Applications of Composites, Fibers, Resins and other materials for composite manufacturing, manufacturing techniques of composites, Introduction to polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon fiber composites.

Module -5: STEELS & SUPER ALLOYS **8L Hrs**

Steels for aircraft structures: Introduction, Basic principles of steel metallurgy, Maraging steel, Medium-carbon low-alloy steel, Stainless steel

Superalloys for gas turbine engines: Introduction, Nickel-based super alloys, Iron–nickel super alloys, Cobalt super alloys, Thermal barrier coatings for jet engine alloys, advanced materials for jet engines

Text Books:

1. Adrian P. Mouritz, "Introduction to aerospace materials", Woodhead Publishing Limited, 2012, ISBN 978-1-85573-946-8
2. George E. Dieter "Mechanical Metallurgy", McGraw Hill Publications
3. William D. Callister, "Materials Science and Engineering: an Introduction", John Wiley and sons

Reference Books:

1. Brian Cantor, Hazel Assender and Patrick Grant, "Aerospace Materials", Institute of Physics Publishing, ISBN: 0 7503 0742 0
2. Sam Zhang, Dongliang Zhao "Aerospace Materials Handbook" CRC Press Taylor & Francis Group, ISBN: 978-1-4398-7330-4

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS271
TITLE OF THE COURSE : COMPOSITES LAB
L: T/A: P: C : 00: 00: 03: 00 : 1.5

1) Fabrication of 200X200 mm- 4 layer laminate by hand lay-up set up
2) Fabrication of 200X200 mm- 4 layer laminate by Vacuum Bagging set up
3) Curing of 200X200 mm- 4 layer laminate by Auto clave set up
4) Fabrication of hollow shaft by filament winding
5) Non-destructive test (Ultrasonic test) to compare the quality of product manufacture by hand layup, vacuum bagging, and Auto clave setup.
6) Tensile test of composite material as per ASTM
7) Flexural testing of composite materials as per ASTM

SEMESTER/YEAR : III SEM / II YEAR
COURSE CODE : 16AS272
TITLE OF THE COURSE : FLUID MECHANICS LAB
L: T/A: P: C : 0 : 0: 3: 0 : 1.5

Course Learning Objectives:

This course will enable students to:

- Conduct experiments on using flow measurement devices including Notch, Venturi Meter, orifice meter and rotameter
- Conduct experiments to calculate major and minor losses in pipes
- Basic understanding of fluid machinary

Course Outcomes:

Upon successful completion of this course, the students:

- Understand major and minor losses in pipe flow
- Understand various methods to calculate discharge using different flow measurement devices including Notch, Venturi Meter, orifice meter
- Determine Performance characteristics of pumps and turbines

LIST OF EXPERIMENTS:

1. Measurement of force and centre of pressure on a plane surface
2. Study of potential flows
3. Verification of Bernoulli's theorem – Pressure measurement with pitot static tube
4. Performance test on air blower
5. Determination of friction factor for flow through pipes
6. Loss of Head on Pipe Fittings Apparatus-To determine and compare pressure drop across various pipe settings
7. Determination of the Coefficient of Discharge of the Given Orifice Meter**.**
8. Determination of the Coefficient of Discharge of the Given Venturimeter.
9. Determination of the Coefficient of Discharge of the Given Notch Apparatus**.**
10. Calculation of the Rate of Flow Using Rotameter.
11. Performance test on pumps and turbines.
12. Reynolds apparatus.

IV SEM

SEM/YEAR : IV SEM
COURSE CODE : 16MA202
TITLE OF THE COURSE : ENGINEERING MATHEMATICS –IV
L: T/A:P: C : 4 :0: 0 : 0 : 4

Course objectives

1. Learn techniques from basic probability
2. Understand complex integration
3. Evaluate real integrals using complex analytic techniques
4. Understand the numerical techniques for differentiation and integration

Course outcomes

1. Analyze basic communication systems model using probabilistic techniques
2. Apply probability for computer network modelling
3. Evaluate real integrals using complex analysis
4. Estimate the integral of complex functions using numerical methods.

ELEMENTARY FUNCTIONS (5 hours)

Exponential and logarithmic functions, Complex powers, Trigonometric and Hyperbolic Functions.

INTEGRATION IN THE COMPLEX PLANE (7 hours)

Complex Integrals, Cauchy-Goursat Theorem, Independence of Path, Cauchy's Integral Formulas and Their Consequences, Cauchy's Two Integral Formulas, Some Consequences of the Integral Formulas, Applications.

SERIES AND RESIDUES (8 hours)

Sequences and Series, Taylor Series, Laurent Series, Zeros and Poles, Residues and Residue Theorem, Some Consequences of the Residue Theorem, Evaluation of Real Trigonometric Integrals, Evaluation of Real Improper Integrals, Applications.

INTRODUCTION TO PROBABILITY THEORY (8 hours)

Axiomatic construction of the theory of probability, independence, conditional probability, And Baye's Theorem. Bernoulli trials.

RANDOM VARIABLES (9 hours)

Random variables, probability distributions, functions of random variables; Standard Univariate discrete and continuous distributions and their properties, mathematical expectations, Moments,Moment generating function and Characteristic function.

NUMERICAL METHODS (8 hours)

Mathematical modelling and engineering problem solving, Roots of equations, Newton Cote's Formula, Numerical Integration and Differentiation.

Text Books:

1. A First course in complex analysis with applications, Dennis Zill and Patrick Shanahan,Jones and Bartlett publishers.
2. A First Course in Probability, S. Ross, Pearson International Edition, 9th Edition
3. Numerical methods for engineers, Chapra and Canale, McGraw Hill Education, 7th edition.

Reference Books:

1. Complex Variables and applications, Brown and Churchill, McGraw Hill Education, Eighth Edition.
2. Probability, Statistics and Statistics with Reliability, Queuing, and Computer Science Applications, Kishore Trivedi, Prentice Hall, 2nd Edition
3. Probability and Random Processes, S. Miller and Childers, Elsevier Inc.,Second Edition
4. A First Course in Numerical Methods, Ascher and Grief, SIAM 2011

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS207
TITLE OF THE COURSE : AERODYNAMICS – I
L: T/A: P: C : 03: 01: 00:00:04

Course Learning Objectives:

This course will enable students to:

- To introduce the concepts of mass, momentum and energy conservation relating to aerodynamics.
- To make the student understand the concept of vorticity, irrotationality, theory of airfoils and wing sections
- Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and study the incompressible over finite wings
- To introduce the basics of viscous flow.

Course Outcomes:

Upon successful completion of this course, the students:

- Potential flows and Viscous flows
- Understanding of flow past streamlined bodies and bluff bodies
- Lift generation mechanisms, Lifting line theory and applications
- Boundary layer theory: Laminar and turbulent flows

Module -1: INTRODUCTION TO LOW SPEED FLOW 8L Hrs

Potential flow analysis, Euler equation, incompressible Bernoulli's equation. circulation and Vorticity, Green's lemma and Stoke's theorem, Barotropic flow, kelvin's theorem, streamline, stream function, irrotational flow, potential function, equipontential lines, elementary flows and their combinations.

Module -2: TWO DIMENSIONAL INVISCID INCOMPRESSIBLE FLOW 9L+2THrs

Scalar and vector fields, velocity potential, line, surface and volume integrals, circulation and lift generation, Kutta-Joukovskii theorem, Source Flow, Sink flow, doublet flow, Ideal Flow over a circular cylinder, D'Alembert's paradox, magnus effect, Kutta-joukowski's theorem, starting vortex, kutta condition, real flow over smooth and rough cylinder.

Module -3: AIRFOIL THEORY 9L+2THrs

Cauchy-Riemann relations, complex potential, methodology of conformal transformation, Kutta Joukowski transformation and its applications, Classical thin airfoil theory for symmetric and asymmetric airfoils and its applications.

Module -4: SUBSONIC WING THEORY 9L+2THrs

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. Simplified horse-shoe vortex model, formation flight, influence of downwash on tail plane.

Module -5: INTRODUCTION TO BOUNDARY LAYER THEORY 9L+2THrs

Boundary layer and boundary layer thickness, displacement thickness, momentum thickness, energy thickness, shape parameter, boundary layer equations for a steady, two dimensional incompressible flow, boundary layer growth over a flat plate, critical Reynolds number, Blasius solution, basics of turbulent flow.

Text Books:

1. Houghton, E.L., and Caruthers, N.B., "Aerodynamics for Engineering students", Edward Arnold Publishers Ltd., London, 1989.
2. Anderson, J.D., "Fundamentals of Aerodynamics", McGraw Hill Book Co., 1999

Reference Books:

1. Milne Thomson, L.H., "Theoretical Aerodynamics",, Macmillan, 1985
2. John J Bertin., "Aerodynamics for Engineers", Pearson Education Inc, 2002
3. Clancy L. J. "Aerodynamics", Sterling book house, New Delhi. (2006), ISBN 13: 9780582988804
4. Kuethe, A.M and Chow, C.Y, "Foundations of Aerodynamics", Fifth Edition, John Wiley & Sons,2000.
5. Louis M. Milne-Thomson, "Theoretical Aerodynamics", Imported Edition, Dover Publications, USA (2011), ISBN 9780486619804.

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS208
TITLE OF THE COURSE : AEROSPACE STRUCTURAL MECHANICS
L: T/A: P: C : 03: 01: 00:00:04

Course Learning Objectives:

This course will enable students to:

- Understand various aerospace structures and loading conditions
- Study the behavior of Thin-Walled beams(TWBs)under static, bending & torsional conditions
- Understand buckling of TWBs under combined axial and lateral loading conditions

Course Outcomes:

Upon successful completion of this course, the students:

- Analyze stress & strain under various loading conditions using Thin-Walled Beam theory
- Analyze single and multi-cell closed sections using Bredt-Batho theory

Module-1: INTRODUCTION TO AEROSPACE STRUCTURES 8L Hrs

Semi-monocoque aerospace structures - Loads and Design considerations; construction concepts, layout, nomenclature and structural function of parts, strength v/s stiffness based design.
Torsion of non-circular prismatic beams, importance of warping; St. Venant's or Prandtl's formulation; Membrane analogy and its application to narrow rectangular cross-section.

Module-2: THIN-WALLED BEAM (TWB) THEORY 9L+2T Hrs

General formulation of Thin-Walled Beam (TWB) Theory, Cartesian and midline systems, CSRD & thin-wall assumptions, general expressions for dominant displacement, strain and stress fields, equilibrium equations in midline system, stress resultants and general boundary conditions.

Module -3: TORSION AND BENDING OF CLOSED TWBS 9L+2T Hrs

Torsion of single and multi cell closed sections - Bredt-Batho theory, shear flow, torsion constant, free warping calculation, and concept of center of twist, torsional equilibrium equation and boundary conditions. Torsion of open TWBs without warp restraint, primary & secondary warping, St. Venant torsion constant.

Module -4:Torsion and Bending of open TWBs 9L+2T Hrs

Uncoupled bending of open, closed, single cell, multi-cell TWBs - axial stress, shear flow, shear

centre, displacement analysis.
Torsion of open section TWBs with primary warp restraint - concept and theory of torsion bending, torsion bending constant, secondary warping restraint. Unsymmetric bending and coupled bending torsion analysis.

Module -5: BUCKLING OF TWBS 9L+2T Hrs

Concept of structural instability, flexural buckling analysis, bending of beams under combined axial and lateral loads, short column and inelastic buckling. Pure torsional buckling and coupled flexural-torsional buckling of open TWBs.
Introduction to the concept of buckling of plates, local buckling of TWBs. Introduction to buckling and post-buckling of stiffened skin panels, ultimate load carrying capacity of a typical semi-monocoque TW box-section. Introduction to tension-field beams.

Text Books:

1. Megson, T. H. G., "Aircraft Structures for Engineering Students", Butterworth-Heinemann, 4th Ed., 2007
2. Peery, D. J., "Aircraft Structures", McGraw-Hill Education, 1st Ed., 1950.

Reference Books:

1. Donaldson, B. K., "Analysis of Aircraft Structures", Cambridge Aerospace Series, 2nd Ed., Cambridge University Press, 2008.
2. Sun, C. T., "Mechanics of Aircraft Structures", Wiley-Interscience, 1998.
3. Niu, M., "Airframe Stress Analysis & Sizing", AdasoAdastra Engineering Center, 1998.

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS209
TITLE OF THE COURSE : MECHANISMS AND MACHINE THEORY
L: T/A: P: C : 03: 01: 00: 00:04

Course Learning Objectives:

This course will enable students to:

1. Understand different types of mechanisms and kinematic pairs
2. Understand the techniques for studying the dynamics of machines and its components
3. Study Governors and effect of Gyroscopic couple on aircrafts

Course Outcomes:

Upon successful completion of this course, the students:

1. Analyse different types of mechanisms using analytical and graphical methods
2. Solve problems on balancing of reciprocating and rotating masses
3. Determine the performance characteristics of Governors and Gyroscope

Module -1: **BASICS OF MECHANISMS 7L Hrs**

Definitions Link or element, kinematic pairs, Degrees of freedom, Grubler's criterion (without derivation), Kinematic chain, Mechanism, Structure, Mobility of Mechanism, Inversion, Machine. Kinematic Chains and Inversions: Inversions of Four bar chain; Single slider crank chain and Double slider crank chain.

Straight line motion mechanisms. Intermittent Motion mechanisms -Geneva wheel mechanism and Ratchet and Pawl mechanism. Toggle mechanism, Pantograph

Module -2: VELOCITY AND ACCELERATION ANALYSIS 8L Hrs + 4T Hrs

Velocity and Acceleration Analysis of Mechanisms (Analytical Method): Velocity and acceleration analysis of four bar mechanism, slider crank mechanism using complex algebra method. Freudenstein's equation for four bar mechanism and slider crank mechanism. Function Generation for four bar mechanism

Velocity Analysis by Instantaneous Center Method: Definition, Kennedy's Theorem, Determination of linear and angular velocity using instantaneous center method Klein's Construction: Analysis of velocity and acceleration of single slider crank mechanism.

Module -3: FORCE ANALYSIS OF MECHANISMS 9L Hrs + 4T Hrs

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 Dynamic Force Analysis: D'Alembert's principle, inertia force, inertia torque. Dynamic force analysis of four- bar mechanism and slider crank mechanism.

Module -4: BALANCING OF ROTATING MASSES, GOVERNORS AND GYROSCOPE 8L Hrs + 4T Hrs

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: Discuss the approaches and challenges in balancing and single cylinder engine, multi cylinder-inline engine, V-type engines, and radial engines (direct and reverse crank method)

Module -5: GOVERNORS AND GYROSCOPES 6L Hrs+2T Hrs

Governors: Concept of Controlling force, Stability, sensitiveness, Isochronism, effort and power in governors Types of governors; force analysis of Porter and Hartnell governors.

Gyroscope: Vectorial representation of angular motion. Gyroscopic couple, effect of gyroscopic couple on ship, plane disc, aeroplane, stability of aircrafts.

Text Books:

1. Sadhu Singh, Theory of Machines, Pearson Education. 2nd edition, 2007.
2. Rattan S.S. Theory of Machines, Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition, 2009

Reference Books:

1. J.J. Uicker, G.R. Pennock, J.E. Shigley, “Theory of Machines & Mechanisms”, Oxford 3rd Ed. 2009
2. A.G.Ambekar, “Mechanism and Machine Theory”, PHI, 2007

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS210
TITLE OF THE COURSE : AIRCRAFT PROPULSION
L: T/A: P: C : 03: 00: 00:00:03

Course Learning Objectives:

This course will enable students to:

- Understand the working principles of gas turbine and ramjet propulsion systems, the design principles of inlets, combustion chambers, nozzles used in them
- Understand the operation of compressors and turbines in gas turbine propulsion systems
- Understand rocket propulsion

Course Outcomes:

Upon successful completion of this course, the students:

- Analyze the engineering concepts of propulsion systems
- Determine the performance characteristics of compressors and turbines
- Choose the propellant based on the application.

Module -1: INTRODUCTION TO PROPULSION TECHNIQUES 7L Hrs

Introduction: Classification of power plants - Methods of aircraft propulsion – Propulsive efficiency – Specific fuel consumption - Thrust and power- Factors affecting thrust and power. Gas turbine engine: Illustration of working of Gas turbine engine - Characteristics of turboprop, turbofan and turbojet– Methods of Thrust augmentation.

Module -2: PROPELLER THEORY AND PERFORMANCE 7L Hrs

Propeller Blade Theory: Momentum theory, Blade element theory, combined blade element and momentum theory, propeller power losses.

Propeller performance: prediction of static thrust- and in flight, negative thrust, prop fans, ducted propellers, propeller noise, propeller selection, propeller charts.

Module -3: INLETS AND COMBUSTION 11 L Hrs

Nozzles : Subsonic and supersonic inlets – Relation between minimum area ratio and external deceleration ratio , Starting problem in supersonic inlets –Modes of inlet operation, jet nozzle – Efficiencies – Over expanded, under and optimum expansion in nozzles – Thrust reversal.

Combustion Chamber: Classification of Combustion chambers - Combustion chamber performance – Flame tube cooling – Flame stabilization.

Module -4: COMPRESSORS 8L Hrs

Compressor types: Introduction to centrifugal compressors, Axial flow compressor- geometry-

twin spools- three spools- stage analysis- velocity polygons- degree of reaction – radial equilibrium theory- performance maps.

Module -5: TURBINES **9L Hrs**

Axial and radial flow turbines: geometry- velocity polygons- stage analysis- performance maps- thermal limit of blades and vanes.

Text Books:

1. Hill,P.G. and Peterson, C.R. "Mechanics and Thermodynamics of Propulsion", Pearson India,2nd edition,2009,ISBN-13: 978-8131729519
2. Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H, "Gas Turbine Theory", DORLING KINDERSLEY,5th edition,2002,ISBN-13: 978-8177589023

Reference Books:

1. G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series, 1985, ISBN-13: 978-0915928972.
2. G.P.Sutton, "Rocket Propulsion Elements", Wiley India Pvt Ltd, 7th Edition, 2010, ISBN-13: 978-8126525775.
3. W.P.Gill, H.J.Smith& J.E. Ziurys, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 4th revised edition,2007,ISBN-13: 978-8120417106.

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS211
TITLE OF THE COURSE : PRODUCT DESIGN – I
L: T/A: P: C : 02:00: 02: 00:03

Course Learning Objectives:

This course will enable students to:

1. Acquire practical knowledge regarding conceptualization, design and development of a new product.
2. Understanding costing and economic decision making
3. Familiarization with design software on 3D modeling, section of solids, orthographic view and dimensioning

Course Outcomes

Upon successful completion of this course, the students:

1. Understand the need of a new product, the product life cycle and the product design process.
2. Get awareness of the role of multiple functions in creating a new product (e.g. marketing, finance, industrial design, engineering, production).
3. Get competence with a set of tools and methods for product design and development.
4. Generate detailed 3D drawing

Module 1: INTRODUCTION 8 L Hrs

Importance of product design, life cycle of a product, steps involved in the design process, communication during the design process, team behavior and tools, design review, delta design exercise.

Module 2: IDENTIFICATION AND UNDERSTANDING OF CUSTOMER NEEDS 8 L Hrs

Voice of customer, gather raw data from customers, interpret raw data in terms of customer needs, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. Requirements capture, development of product design specifications, quality function deployment (QFD) technique, case studies in QFD.

Module 3: CONCEPT GENERATION AND EVALUATION 8 L Hrs

Generating engineering specifications, functional analysis and design, concept generation methods, creativity and problem solving, creativity method, creative idea evaluation, TRIZ, axiomatic design. Concept evaluation: Information representation, concept evaluation overview, evaluation techniques based on 1) feasibility judgment, 2) GO-NO-GO screening, 3) technological readiness, 4) basic decision matrix (Pugh's Method). Time value of money, cost

comparison, profitability of investment, sensitivity and break even analysis.

Module 4: PRODUCT ARCHITECTURE AND PROTOTYPING 8 L Hrs

Product Architecture- What is product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues.

Prototyping- Prototyping basics, principles of prototyping, technologies, planning for prototypes

Module 5: SOFTWARE BASICS AND 3D MODELING (ONLY FOR INTERNALS) 10 L Hrs

Introduction to software (CATIA), CAD Basics, solid modeling, surface modeling (Theory on Bezier curves), sectioning, views, dimensioning, 2D drawing preparation, bill of materials Product design of own choice – part drawing, exploded view and assembly

Text books

1. Dieter, G. E., Engineering Design: a materials and processing approach, McGraw Hill International Series, 2000.
2. Ullman, D. G., Mechanical Design Process, McGraw Hill, 2004.

Reference books

1. Ulrich, K. T. and Eppinger, S. D., Product Design and Development, Irwin McGraw Hill, 2000.
2. Eide,R., Jenison, R. D., Marshaw , L. H., and Northup L. R., Introduction to Engineering Design, McGraw Hill Basic Engineering Series and Tools, 1998.

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS273
TITLE OF THE COURSE : AEROSPACE STRUCTURES
LAB L: T/A: P: C : 00: 00: 03: 00:1.5

Course Learning Objectives:

This course will enable students to:

- Conduct experiments on various structural elements like beams, columns, frames and pressure vessels
- Conduct experiments on different testing machines like universal testing machine, fatigue testing machine, creep testing machine
- Calculate tensile strength, fatigue strength and creep strength of different materials

Course Outcomes:

Upon successful completion of this course, the students:

- To understand the basic concepts of material science and real experience getting to determine different strength properties.
- To understand the application of Aircraft material science
- To understand various aerospace structural components like longerons, stringers, bulk head and ribs
- To understand different instrumentation and different industry standards

LIST OF EXPERIMENTS:

1. Deflection of beams using Beam testing set-up
2. Deflection of columns using Column testing set-up
3. Determination of stress in thin wall pressure vessel
4. Pin jointed frame analysis
5. Determination of bending stress in beam
6. Determination of Fatigue strength
7. Vibration testing
8. Creep testing
9. Demonstration of aerospace structure

SEMESTER/YEAR : IV SEM / II YEAR
COURSE CODE : 16AS274
TITLE OF THE COURSE : MATERIAL TESTING
LAB L: T/A: P: C : 00: 00: 03: 00:1.5

Course Learning Objectives:

This course will enable students to:

- Conduct various mechanical testing of materials

Course Outcomes:

Upon successful completion of this course, the students:

- Analyse the results of different mechanical testing of materials

LIST OF EXPERIMENTS:

1. Tension Test- To determine mechanical properties such as ultimate tensile strength, elastic modulus, proportionality limit, yield point, fracture stress, percentage elongation & reduction in area of metals & alloys and also study the behaviour of material & characterize types of fracture under tensile load.
2. Compression Test -To conduct compression test on the given material and to determine properties such as compressive strength, modulus of elasticity, percentage constriction & percentage increase in area.
3. Shear Test - To determine ultimate shear stress of the given specimens in single and double shear.
4. Bending Test -To study the characteristics of materials under the gradually increasing flexural loading and to determine Modulus of rupture, Modulus of elasticity, Maximum shear stress.
5. Impact Test - (Charpy and Izod) - To find out the impact strength of the given notched specimens.
6. Brinell hardness Test -To determine the Brinell Hardness Number (BHN) of the given specimens.
7. Vicker's Hardness Test - To determine Vickers Hardness Number for a given specimen.
8. Wear Test - To determine the wear rate of different materials by using pin and disc apparatus.

V Sem

SEMESTER/YEAR	**:**	**V SEM / III YEAR**
COURSE CODE	**:**	**16AS301**
TITLE OF THE COURSE	**:**	**AERODYNAMICS – II**
L: T: P: S/P: C	**:**	**03:01: 00:00: 04**

COURSE OBJECTIVES

This course will enable students to:

1. To provide students with an overview of effects of Compressible flows.
2. Analyze how the aerodynamics affects the aircraft design and operation
3. To make students understand the characteristics of normal and oblique shock waves.
4. To make students learn about the effects of high-speed flows.

COURSE OUTCOMES

Upon successful completion of this course, the students:

1. Apply the essential facts, concepts and principles of compressible flows
2. Utilize the concepts of normal shock phenomenon
3. Analyze the concepts of oblique shock and expansion waves
4. Acquire the knowledge of differential equations of motion, governing Compressible flows.
5. Measure the parameters of high-speed flows.

Module 1: ONE DIMENSIONAL COMPRESSIBLE FLOW: 7L hrs.

Mass, Momentum, Energy equations, velocity of sound, adiabatic steady state flow equations, Flow through convergent-divergent nozzle, Performance under various back pressures.

Module 2: NORMAL SHOCK: 8L hrs

Prandtl Meyer equation and Rankine – Huguenot relation, Normal shock equations: Property ratios in terms of upstream Mach number, Moving Normal Shock wave, Numerical problems

Module 3: OBLIQUE SHOCKS AND EXPANSION WAVES: 8L hrs

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, Pitot static tube, corrections for subsonic and supersonic flows.

Module 4: STEADY STATE COMPRESSIBLE FLOWS: 8L hrs

Basic potential equations for compressible flow. Linearization of potential equation-small perturbation theory. 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: 8L hrs

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

Text Books:

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

Reference Books:

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

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS302
TITLE OF THE COURSE : INTRODUCTION TO SPACE TECHNOLOGY L: T: P: S/P: C : 04:00: 00:00: 04

COURSE OBJECTIVES

This course will enable students to:

- Understand the harsh environment of space
- Learn the governing laws of planetary motion
- Know various launch systems and launching stages
- Understand the function of spacecraft subsystems

COURSE OUTCOMES

Upon successful completion of this course, the students:

- Apply orbital mechanics formula and tools to spacecraft mission design
- Select appropriate launch systems and understand their effect on satellite and payload design and performance.
- Select suitable payloads and sensors for various space missions

MODULE 1: SPACE ENVIRONMENT 8L hrs.

Earth's Atmosphere, Neutral atmosphere, Plasma, Solar Cycle, Solar Radiation, Radiation Belts, Earth's Magnetic field, Space Debris, Electro static charging, meteoroid impact, Effect of environment on Space craft, Aerodynamic drag

MODULE 2: ORBITAL MECHANICS 8L hrs.

Orbital velocity, escape velocity, Keplar's law of planetary motion, two body motion, linear and angular momentum, Keplar's second law, Equation of trajectory

MODULE 3: SPACE PROPULSION 7L hrs.

Space Missions, Principle of rocket launching, Rocket Propulsion, Staging, Solid propellant, liquid propellant and cryogenic Propulsion, Electric Propulsion, Electro Thermal Thrusters, Sounding rockets, PSLV, GSLV, Launch window

MODULE 4: SATELLITE & SUBSYSTEMS 8L hrs.

Power Systems, Attitude Determination and Control, Guidance and Navigation, Avionics, Telemetry, tracking and command, Communication, Structure and Mechanisms, Thermal System

MODULE 5 INTRODUCTION TO TEST FACILITY AND TESTING FOR SPACE COMPONENTS AND SYSTEM 8L hrs.

Types of Tests; Test Facilities and Safeguards; Safety and Environmental Concerns; Monitoring and Control of Toxic Materials and Exhaust Gases; Instrumentation and Data Management; Reliability and Quality Control; Flight Testing. Assembly integration test, comprehensive test & test vacuum chamber and comprehensive test & test vibration facilities.

Text Books:

1) Wertz, J.R. and W.J. Larson, eds. Space Mission Analysis and Design (SMAD). 3rd ed. Microcosm Press, 1999. ISBN: 1881883108.
2) Pisacane, V.L. and R.C. Moore. Fundamentals of Space Systems. Oxford, 1994. ISBN: 0195074971.
3) Fortesque, P.W. and J.P.W. Stark. Space Systems Engineering. John Wiley and Sons, 1995.

Reference Books:

1) Griffin, M.D. and J.R. French. Space Vehicle Design. AIAA, 1991. ISBN: 0930403908.
2) Morgan, W.L. and G.D. Gordon. Communications Satellite Handbook. 1989. ISBN: 0471316032.

Other Sources:

https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-851-satellite-engineering-fall-2003/lecture-notes/

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS303
TITLE OF THE COURSE : AIRCRAFT PERFORMANCE
L: T: P: S/P: C : 03:01: 00:00: 04

AIRCRAFT

PERFORMANCE

COURSE OBJECTIVES

This course will enable students to:

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

COURSE OUTCOMES

Upon successful completion of this course, the students

1. Understand Equations of motion for unaccelerated steady flight.
2. Develop the equation for the steady performance of level, climb and glide flight
3. Calculate the Range and Endurance of propeller driven and jet driven airplanes
4. Enumurate aircraft performance like takeoff, and landing of accelerated Flight
5. Understand the V-n diagram and calculate the Maneuver performance of the accelerated Flight
6. Understand the different phases of weight estimations required for designing of aircrafts

Module 1: THE EQUATIONS OF MOTION STEADY UNACCELERATED FLIGHT

8L hrs.

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 8L hrs.

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), Gliding flight, Range during glide, minimum rate of sink and shallowest angle of glide.

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.

Module 3: RANGE AND ENDURANCE: 8L hrs.

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 8L hrs.

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: MANEUVERER PERFORMANCE 7L hrs.

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.

Text Books:

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

Reference Books:

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

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS304
TITLE OF THE COURSE : PRINCIPLES OF MANAGEMENT & ECONOMICS FOR ENGINEERS
L: T: P: S/P: C : 03:01: 00:00: 04

COURSE OBJECTIVES

This course will enable students to:

- To help the students to understand the fundamental concepts and principles of management; the basic roles, skills, functions of management, various organizational structures and basic knowledge of marketing
- To impart knowledge, with respect to concepts, principles and practical applications of Economics, which govern the functioning of a firm/organization under different market conditions

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Understand needs, functions, roles, scope and evolution of management
- Understand importance, purpose of planning and hierarchy of planning and also analyse Its types
- Discuss decision making, organizing, staffing, directing and controlling.
- Select the best economic model from various available alternatives.
- Understand various interest rate methods and implement the suitable one.
- Estimate various depreciation values of commodities.
- Prepare the project reports effectively.

Module 1: MANAGEMENT 8L hrs.

Introduction - Meaning - nature and characteristics of Management, Scope and Functional areas of management - Management as a science, art of profession - Management & Administration - Roles of Management, Levels of Management, and Development of Management Thought- early management approaches – Modern management approaches. Planning: Nature, importance and purpose of planning process Objectives - Types of plans(Meaning Only) - Decision making Importance of planning - steps in planning & planning premises - Hierarchy of plans.

Module 2: ORGANIZING AND STAFFING **8L hrs.**

Nature and purpose of organization Principles of organization - Types of organization - Department Committees Centralization Vs Decentralization of authority and responsibility - Span of control - MBO and MBE (Meaning Only) Nature and importance of staffing--Process of Selection & Recruitment (in brief). Directing & Controlling: Meaning and nature of directing Leadership styles, Motivation Theories, Communication - Meaning and importance - coordination, meaning and importance and Techniques of Co Ordination. Meaning and steps in controlling - Essentials of a sound control system - Methods of establishing control (in brief).

Module 3: INTRODUCTION: ENGINEERING AND ECONOMICS **8L hrs.**

Problem solving and decision making, Laws of demand and supply, Difference between Microeconomics Macroeconomics, equilibrium between demand & supply, elasticity of demand, price elasticity, income elasticity. Law of Returns, Interest and interest factors, simple and compound interest, Cash flow diagrams, personal loans and EMI payment calculation with flexible interest rates, Discussion and problems.

Module-4 **8L hrs.**

Present, future and annual worth and rate of returns: Basic present worth comparisons, Present worth equivalence, Assets with unequal lives and infinites lives, future worth comparisons, payback comparisons, Equivalent annual worth comparisons, situations for annual worth comparisons. Asset life, Rate of return, minimum acceptable rate of return, IRR anomalies and misconceptions, Cost of capital, comparisons of all present future and annual worth with IRR, product costing, Balance sheet, Discussions and problems.

Module 5: COSTING AND DEPRECIATION **8L hrs.**

Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems.

Text Books:

1) Principles of Management by Tripathy and Reddy
2) Mechanical estimation and costing, T.R. Banga & S.C. Sharma, 17th edition 2015
3) Engineering Economy, Riggs J.L. McGraw Hill, 2002
4) Engineering Economy, Thuesen H.G. PHI , 2002

Reference Books:

1) Management Fundamentals - Concepts, Application, Skill Development - Robers Lusier Thomson
2) Basics of Engineering Economy, Leland Blank & Anthony Tarquin, McGraw Hill Publication (India) Private Limited
3) Engineering Economics, R.Paneerselvam, PHI publication
4) Management & Engineering Economics, Ravi Kumar R, Sunstar Publications
5) Fundamentals of Management: Essential Concepts and Applications, Pearson Education, Robbins S.P. and Decenzo David A.
6) Economics: principles of economics, and gregory mankiw, cengage learning

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS371
TITLE OF THE COURSE : AEROSPACE PROPULSION LAB
L: T: P: S/P: C : 00:00: 03:00: 1.5

COURSE LEARNING OBJECTIVES

This course will enable students to:

- Conduct experiments on using devices including bomb calorimeter, viscometers and gas turbine engines.
- Conduct experiments to viscosity and efficiency of engines.
- Basic understanding of performance of engines.

COURSE OUTCOMES

Upon successful completion of this course, the students:

- Understand propellers and there performance.
- Determine Performance characteristics of Gas turbine engines.

LIST OF EXPERIMENTS:

1. Flash and Fire point of fuel
2. Redwood viscometer
3. Saybolt Viscometer
4. Bomb Calorimeter
5. Performance of Two stroke engine
6. Performance of Four stroke engine
7. Performance of propeller
8. Description of Gas Turbine Engine

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS372
TITLE OF THE COURSE : FLIGHT PHYSICS LAB
L: T: P: S/P: C : 00:00: 03:00: 1.5

COURSE LEARNING OBJECTIVES:

This course will enable students to:

- Conduct experiments on aerofoil, water flow channel.
- Conduct experiments on pitot and static tubes.
- Basic understanding of flow visualization.

COURSE OUTCOMES:

Upon successful completion of this course, the students:

- Understand tubes and there flow performance.
- Determine Performance and force measurement, pressure distribution in ae foil and blunt body.

LIST OF EXPERIMENTS

1. Measurement of pressure distribution over an aero foil
2. Measurement of pressure distribution over a blunt body
3. Flow visualization in water flow channel
4. Force measurement
5. Flow over flat plate
6. Understanding pitot and static tubes

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS311
TITLE OF THE COURSE : WIND TUNNEL MODEL TESTING
L: T: P: S/P: C : 03: 00: 00:03

COURSE LEARNING OBJECTIVES

This course will enable students to:

1. To understand the need for experimental aerodynamics, types of wind tunnels and their application areas
2. To understand the design of wind tunnels, test section & drive system
3. To understand various types of test techniques & types of measurements and uncertainties
4. Acquire knowledge on design on models for wind tunnel testing
5. To carry out simple experiments in the DSU wind tunnel

COURSE OUTCOMES:

Upon successful completion of this course, the students will be able to:

1. Design models for wind tunnel testing both for low speed and high speed wind tunnels
2. Having hands-on training on carrying out wind tunnel tests and analyze results
3. Ability to select proper measuring instruments based on need
4. Ability to analyze and present tested results

Module 1: INTRODUCTION TO WIND TUNNELS 8L Hrs

Aerodynamics, Properties of Air and Water, Similarity Parameters, Incompressible Flow, Types of Wind Tunnels and their applications

Module 2: COMPONENTS OF WIND TUNNEL SYSTEMS 8L Hrs

Overall Objectives, Power Considerations, Energy Ratio of typical Wind Tunnels, Cooling, Test Section Flow Quality, Drive Systems, Wind Tunnel Construction, Test Section Inserts, Safety

Module 3: MEASUREMENT TECHNIQUES & CALIBRATION OF TEST SECTION 9L Hrs

Flow Visualization Techniques, Pressure, Force and Moment measurements, Boundary Layer measurements, External and Internal Balances, Balance requirements and Specifications, Installation in models, Calibration and use of transonic & supersonic wind tunnels, Design of models and instrumentation systems

Module 4: SPECIAL TEST TECHNIQUES & DATA REDUCTION 8L Hrs.

Data Reduction from Wind Tunnel Tests, Scale Effects, Corrections to Wind Tunnel Data, Measurement Uncertainties

Module -5 EXPERIMENTS IN DSU WIND TUNNEL 6L Hrs

Design and manufacturing of simple models for testing in DSU low speed wind tunnel, analyses of experimental findings and documentation

Text Books:

3. Jewel B. BARLOW, William H. RAE Jr., Alan POPE, "Low-Speed Wind Tunnel Testing", John Wiley & Sons, New York, Toronto, 1999, 3rd Edition, ISBN 978-0-471-55774-9
4. Alan Pope and Kennith L Goin, "High-Speed Wind Tunnel Testing", John Wiley and Sons, New York, 1965

Reference Books:

1. Liepmann, H W and Roshko A, Elements of Gas Dynamics", Dover Publications, 2013. ISBN 9780486316857
2. John D Anderson Jr., "Fundamentals of Aerodynamics", 5th Edition, McGraw Hill Education (India) Pvt. Ltd., 2010

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS312
TITLE OF THE COURSE : AIR TRANSPORTATION SYSYEM
L: T: P: C : 03: 00: 00:03

COURSE OBJECTIVES

This course will enable students to:

- Understand the air transport systems.
- Acquire the knowledge of aircraft characteristics, airlines and airport.
- Details the concepts of airspace infrastructure and its requirements for operation and services
- Understand the different concepts of navigation, Communication and environmental systems.
- Understand the Managerial concepts and its aspects behind the air transportation system

COURSE OUTCOMES:

Upon successful completion of this course, the students will be able to:

- Understand the complete insight of Air transportation system.
- Explore the knowledge about basic aircraft characteristics, cabin design and manufacturers.
- Illustrate the detailed structure Airlines, Airports and its Infrastructure
- Understand the different air navigation and environmental systems used for improving the ATS
- List the Managerial aspects of Airlines

Module 1: AIR TRANSPORT SYSTEMS –INTRODUCTION 7L hrs.

Environment, transport and mobility. Systematic description and current challenges. Development of aircraft design driver-speed and range. Development of Airport, Airlines, ICAO, Regulatory Framework and Market Aspects.

Module 2: AIRCRAFT CHARACTERISTICS AND MANUFACTURERS 8L hrs.

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 8L hrs.

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 SYSTEM 8L hrs.

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 AIRLINE 8L hrs.

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

Text Books:

1) Dieter Shmitt, and Valker Gollnick, Air Transport System, Springer, 2016.
2) John G Wensveen, Air Transportation-A Management Prospective, Ashgate Publishing Ltd,
3) 2011.

Reference Books:

1) Mike Hirst, The Air Transportation System, Wood head publishing Ltd, England, 2008.

SEMESTER/YEAR : V SEM / III YEAR
COURSE CODE : 16AS313
TITLE OF THE COURSE : FINITE ELEMENTAL METHODS
L: T: P: C : 03: 00: 00:03

COURSE LEARNING OBJECTIVES

This course will enable students to:

- To enable the students to appreciate the use of finite element methods to analyze structural and dynamic problems.
- To enable the students to understand and perform finite element analysis of 1D and 2D structures.
- To teach the procedure to perform finite element based steady-state and transient response analysis.

COURSE OUTCOMES

Upon successful completion of this course, the students will be able to:

- At the end of the course, the student will be able to
- Calculate element energy functions for 1-D and 2D finite elements.
- Understand and apply Raleigh Ritz method and develop mathematical expressions for bars and beams.
- Understand and appreciate the finite element method in solving simple problems of engineering significance.
- Understand and appreciate the finite element method in solving steady state heat transfer problems.

MODULE 1: Introduction: 8L HRS

Introduction: Equilibrium equations in elasticity subjected to body force, traction forces, and stress-strain relations for plane stress and plane strains. General description of finite element method, application and limitations, types of elements based on geometry. Node numbering, half band width.

MODULE 2: BASIC METHODS 8L HRS

Basic Methods in FEM Euler - Lagrange equation for bar, beam (cantilever / simply supported fixed). Principle of virtual work, principle of minimum potential energy, Raleigh's Ritz method. Direct approach or stiffness matrix formulation of bar element and Galerkin's method.

MODULE 3: INTERPOLATION MODELS **8L HRS**

Interpolation polynomials- linear, quadratic and cubic. Simplex complex and multiplex elements, 2D PASCAL's triangle, CST elements-shape functions and nodal load vector, strain displacement matrix and Jacobian for triangular and rectangular element. Higher Order Elements: LaGrange's interpolation, one dimensional elements-quadratic element and their shape functions. Shape function of 2-D quadrilateral element-linear, quadric element Isoperimetric, sub parametric and super parametric elements.

MODULE 4: 1-D BARS &TRUSSES: **7L HRS**

Solution of 1-D Bars: Solutions of bars and stepped bars for displacements, reactions and stresses by sing penalty approach and elimination approach. Gauss-elimination technique. Trusses: Stiffness matrix of truss element. Numerical problems

MODULE 5: BEAMS & HEAT TRANSFER BEAMS **8L HRS**

Beams & Heat Transfer Beams: Hermite shape functions for beam element, derivation of stiffness matrix. Numerical problems of beams carrying concentrated, UDL and linearly varying loads. Heat transfer: Steady state heat transfer, 1D heat conduction governing equations. Functional approach for heat conduction, Galerkin's approach for heat conduction, 1D heat transfer in thin fins.

Text Books:

1) T.R. Chandrupatla and A.D Belegunde , Finite Elements in Engineering, 3rd Ed PHI.
2) S.S. Rao, Finite Element Method in Engineering,4th Edition, Elsevier, 2006.

Reference Books:

1) R.D. Cook D.S Maltus, M.E Plesha and R.J.Witt, Concepts and applications of Finite Element Analysis, Wiley 4th Ed, 2009
2) J.N.Reddy, Finite Element Method, McGraw -Hill International Edition, 2009.

VI Sem

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS305
TITLE OF THE COURSE : CONTROL THEORY
L: T: P: S/P: C : 03:01: 00:00: 04

Course objectives:

This course will enable students to

1. Understand the concepts of open loop, closed loop systems and types of controllers.
2. Construct signal flow diagram from the Blocks and signal flow graphs.
3. Know about the Bode plot, Nyquist plot, polar plot and Root locus method.

Course outcomes:

After studying this course, students will be able to:

1. Apply the concepts of open loop, closed loop systems and types of controllers.
2. Develop signal flow diagram from the Blocks and signal flow graphs.
3. Interpret the Bode plot, Nyquist plot, polar plot and Root locus method

Module -1 **08 Hrs.**

Introduction: Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers- Proportional, Integral Proportional Integral, Proportional Integral Differential controllers.

Mathematical Models: Transfer function models, models of mechanical systems, models of electrical circuits, DC and AC motors in control systems, Analogous systems: Force voltage, Force current

Module -2 **08 Hrs.**

Block Diagrams and Signal Flow Graphs: Transfer Functions definition, function, block representation of systems elements, reduction of block diagrams, Signal flow graphs: Mason's gain formula

Module -3 **08 Hrs.**

Transient and Steady State Response Analysis: Introduction, first order and second order system response to step, ramp and impulse inputs, concepts of time constant and its

importance in speed of response. System stability: Routh's- Hurwitz Criterion

Module -4 **08 Hrs.**

Root Locus Plots: Definition of root loci, General rules for constructing root loci, Analysis using root locus plots. Frequency Response Analysis: Polar plots, Nyquist stability criterion, Stability analysis, Gain margin and phase margin.

Frequency Response Analysis Using Bode Plots: Bode attenuation diagrams, Stability analysis using Bode plots, Simplified Bode Diagrams.

Module -5 **08 Hrs.**

System Compensation and State Variable Characteristics of Linear Systems: Series and feedback compensation, Introduction to state concepts, state equation of linear continuous data system. Matrix representation of state equations, controllability and Observability, Kalman and Gilberts test

Text Books:

1. Katsuhiko Ogatta, Modern Control Engineering, Pear son Education, 5th edition, 2015, ISBN13: 978-9332550162.

2. M.Gopal, Control Systems Principles and Design, TMH, 4th edition, 2012, ISBN-13: 978-0071333269.

Reference Books:

1. Richard.C.Dorf and Robert.H.Bishop, Modern Control Systems, Pearson Education India, 12th edition, 2013, ISBN-13: 978-9332518629
2. Eronini-Umez, System dynamics & control, Thomson Asia pvt Ltd. Singapore, 2002.
3. Schaum's series, Feedback Control System, 2001.

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS306
TITLE OF THE COURSE : AIRCRAFT SYSTEMS & INSTRUMENTATION
L: T: P: S/P: C : 03:00: 00:00: 03

Course Objectives:

1. To provide the knowledge regarding basic concepts of flight instruments, their significance and operation.
2. To impart the concepts of measurements using air data sensor, Gyroscope and engine data.
3. To impart the basic concepts regarding Avionics systems and also the necessary knowledge on working of avionics system in aircraft.

Course Outcome:

Students will be able to

1. Understand the basics of measurements and different parameters
2. Appreciate the need for general measurements in aviation industry
3. Identify the fundamental cockpit instruments and their working principles
4. Select proper instrumentation requirements for aerospace vehicles
5. Differentiate various sensors and transducers used in aerospace vehicles
6. Apprehend the principles behind temperature, pressure, fuel flow and engine

Module -1 **8 Hrs.**

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 **8 Hrs.**

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 8 Hrs.**

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 **8 Hrs.**

Auxiliary System: Basic Air cycle systems, Vapor Cycle systems, Evaporative vapour cycle systems, Evaporative air cycle systems, Fire protection systems, Deicing and anti-icing systems.

Module -5 **8 Hrs.**

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.

Text Books:

1. Ian Moir and Allan Sea bridge, Aircraft Systems: Mechanical, Electrical and Avionics Sub system Integration', Wiley India Pvt Ltd, 3rd edition, 2012, ISBN-13: 978-8126535217.

2. Pallet, E.H.J., "Aircraft Instruments and Integrated Systems", Longman Scientific and Technical, Indian reprint 1996.

Reference Books:

1. Lalit Gupta and OP Sharma, 'Aircraft Systems (Fundamentals of Flight Vol.IV), Himalayan Books, 2006.

2. Treager,S., "Gas Turbine Technology", McGraw-Hill, 3rd edition,2013,ISBN-13: 978-1259064876.

3. R.W.Sloley and W.H.Coulthard, 'The aircraft Engineers Handbook, No4, INSTRUMENTS', Shroff, 6thEdition, 2005, ISBN-13: 978-8175980518

4.SR Majumdar, 'Pneumatic Systems', Tata McGraw Hill Publishing Co,1st edition,2001,ISBN-13: 978-0074602317.

5. William A Neese, 'Aircraft Hydraulic Systems', Himalayan Books; 2007

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS307
TITLE OF THE COURSE : AIRCRAFT STABILITY & CONTROL
L: T: P: S/P: C : 03:00: 00:00: 03

Course Objectives:

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

Course Outcomes:

1. Understand the contribution of various airframe components on longitudinal static stability in stick fixed condition and responses required from control surfaces to overcome sudden aerodynamic unbalancing.
2. Evaluate stick force required at stick free condition and understand the basic concepts of static directional stability.
3. Predict aileron control forces and flying modes such as Dutch roll, spiral roll, phugoid, long period oscillation with the help of Routh's criterion, for a given stability equation.
4. Estimate the dynamic derivatives for forward speed, pitching velocity, time rate of change of angle of attack, rolling rate and yawing rate.
5. Develop various inter-coupling effects with the motion of aircraft and Examine the response of an aircraft

Module -1: Static Longitudinal Stability and Control-Stick Fixed 8 Hrs.

Historical perspective, Aerodynamic Nomenclature, Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- e Introduction, Trim condition. Static margin, Stick fixed neutral points. Longitudinal control, Power by wire system and EHA

Module -2: Elevator Control and Stick free 8 Hrs.

Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator required for landing, Restriction on forward C.G. range. 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 un accelerated flight, Restriction on aft C.G..

Module -3: Static directional stability and control **8 Hrs.**

Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin, one engine inoperative condition, Weather cocking effect.

Module -4: Static Lateral stability and control **8 Hrs.**

Introduction, definition of roll stability, estimation of dihedral effect. Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, balancing the aileron. Coupling between rolling and yawing moments. Adverse yaw effects, Aileron reversal. Definition of Dynamic longitudinal stability.

Module -5: Dynamic Lateral and Directional Stability **8 Hrs.**

Types of modes of motion: long or phugoid motion, short period motion, Airplane Equations of longitudinal motion. Aerodynamic force and moment representation, Routh's criteria, Factors affecting period and damping of oscillations. Effect of wind shear, flying qualities in pitch, Cooper-Harper Scale. Sideslip excursion. Dutch roll and Spiral instability. Auto- rotation and spin.

Text Books:

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

Reference Books:

1. Bandu N. Pamadi, `Performance, Stability, Dynamics and Control of Airplanes`, AIAA 2nd Edition Series, 2004.
2. John D. Anderson, Jr., "Introduction to flight" McGraw-Hill, International Editions, Aerospace Science Technology Editions, 2000.

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS308
TITLE OF THE COURSE : ORBITAL MECHANICS
L: T: P: S/P: C : 03:00: 00:00: 03

Course Objectives:

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

Course Outcomes:

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

Module -1 **8 Hrs**

Basic knowledge of Space: Overview of major contents of universe, Black body radiation, specific intensity, flux density, luminosity, Basics of radiative transfer (Emission/absorption coefficients, source functions) formation of the solar system, stars, and planets physical processes in the solar system; dynamics of the solar system; physics of planetary atmospheres; individual planets; comets, asteroids, and other constituents of the solar system; extra-solar planets.

Module-2 **8 Hrs.**

Fundamentals of Orbit Mechanics, Orbit Maneuvers: Coordinate Systems, Classical Orbital Elements, Determining the Orbital Elements, the Gauss Problem - General Methods of Solution. Ground trace In-Plane Orbit changes, Hohmann Transfer, Bielliptical Transfer, Plane Changes, Combined Maneuvers and Propulsion for Maneuvers.

Module -3 **8 Hrs.**

Interplanetary Trajectories: Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem.

Module-4 **8 Hrs.**

Satellite Injection and Satellite Perturbations: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.

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

Module- 5 **8 Hrs.**

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. Reusable launch vehicles, future launchers, launch assist technologies. 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.

Text Books:

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

REFERENCE:

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

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS314
TITLE OF THE COURSE : INTRODUCTION TO COMPUTATION FLUID DYNAMICS
L: T: P: S/P: C : 03:00: 00:00: 03

Course Objectives

The course will enable the students to:

1. Introduce Governing Equations of viscous fluid flows
2. Introduce numerical modelling and its role in the field of fluid flow and heat transfer
3. Enable the students to understand the various discretization methods, solution procedures and turbulence modelling.
4. Create confidence to solve complex problems in the field of fluid flow and heat transfer by using high speed computers.

Course Outcomes

1. After completion of the course student would be able to
2. Create numerical modelling and its role in the field of fluid flow and heat transfer.
3. Use the various discretization methods, solution procedures and turbulence modelling to solve flow and heat transfer problems.

Module 1:

Governing equations and boundary conditions 08 Hrs.

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity,Momentum and Energy equations – Chemical species transport – Physical boundary conditions – Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations– Mathematical behaviour of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.

Module 2:

Finite difference and finite volume methods for diffusion 09 Hrs

Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three – dimensional diffusion problems –Parabolic equations – Explicit and Implicit schemes –

Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

Module 3:

Finite volume method for convection diffusion **10 Hrs.**

Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

Module 4:

Flow field analysis **09 Hrs.**

Finite volume methods -Representation of the pressure gradient term and continuity equation – Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

Module 5:

Hands on Simulia/Ansys

Text books

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Second Edition Pearson Education Ltd. 2007.

2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.

Reference

1. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow, Hemisphere" Publishing Corporation, 2004.

2. Chung, T.J. "Computational Fluid Dynamics", Cambridge University, Press, 2002.

3. Ghoshdastidar P.S., "Heat Transfer", Oxford University Press, 2005

4. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS315
TITLE OF THE COURSE : MANUFACTURING TECHNOLOGY
L: T: P: S/P: C : 03:00: 00:00: 03

Course Objectives

1. To introduce the concepts of manufacturing technology
2. To introduce the methodology of aerospace component manufacturing

Course Outcomes:

After studying this course students will be able to:

1. Understand the concepts of casting technology
2. Metal cutting, machining and surface finishing processes.
3. Aero engine manufacturing process.

Module 1: 8 Hrs.

Metal casting and forging –

Introduction, processes and applications of casting Light alloy casting, moulding practice, melting practice, precision investment casting, effect of casting parameters on properties titanium casting, directional solidification, powder metallurgy technique and forging equipment, press, recent trends, quality control aspects of thermo mechanical processing.

Module 2: 8 Hrs.

Metal cutting and joining Process

Alloy requirements, sheet materials, steels, titanium alloys, electron beam welding, brazing of super alloys, ultrasonic machining, water jet cutting, electrochemical processing, laser cutting for rotating machinery components, joining technologies like plasma technique, laser welding, **Module 3: 8 Hrs.**

Composite Materials

Classification based on Matrix Material, Polymer matrix composites (PMC), Carbon matrix Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC). Glass fibre reinforced plastics, high temperature glass fibre composites, carbon fibre reinforced plastics, pressure resisted resin injection, autoclave moulding resin system Concept of composite materials, rule of mixtures.

Module 4: **8 Hrs.**

Additive Manufacturing

Basic Principles of Additive Manufacturing and Processes, Designing for Additive Manufacturing, Multiple Materials, Hybrids, Composite Materials, current and future directions, Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Powder-based AM processes. Printing processes, extrusion based fused deposition modelling object, Stereolithography Micro- and nano-additive, Advantages and application

Module 5: **8 Hrs.**

Aerospace components and protective measures

Major engine components, material trends, component operating environments and material requirements, compressor and turbine discs, blades. Combustion chambers, shafts, bearings Corrosion behavior, coatings and surface treatments, erosion behaviour of compressor components, surface degradation and protection of combustor and turbine components

Text Books:

1. Gibson, Rosen, Stucker, Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing. Springer, 2009.

2. Kalpakjian, S. and Schmidt, S. R., Manufacturing Processes for Engineering Materials, 5th ed., Pearson Education (2007).

4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall India

References:

1. Hopkinson, Hague, Dickens, Rapid Manufacturing: An Industrial Revolution for the Digital Age. Wiley, 2005.

2. Gibson, Advanced Manufacturing Technologies for Medical Applications. Wiley, 2005.

3. Ghosh, A. and Mallik, A. K., Manufacturing Science, Affiliated East West Press (2010).

4. Krishnadas Nair, C. G. and Srinivasan, R., Materials and Fabrication Technology for Satellite and Launch Vehicle, Navbharath Enterprises (2008).

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS373
TITLE OF THE COURSE : SIMULATION LAB
L: T/A: P: C : 03 :00 : 00 :00: 1.5

Course Objective:

1. To know fundamental skills and knowledge required to use MATLAB for the simulation of Engineering systems
2. To introduce concepts of numerical methods and introduce Matlab in an Engineering Framework.

Course Outcomes:

1. Students can able to understand the use of software tools for modelling and analysis of Mathematical concepts for engineering applications
2. Students will be able to model and analyze simple engineering concepts and Its importance in engineering applications

Laboratory Experiments:

1. Familiarization with MATLAB and MATLAB control system toolbox.
2. Representation of scalars, vectors and matrices in MATLAB.
3. Basic 2D and 3D plot using MATLAB.
4. Locating the roots of equations using various methods.
5. Numerical differentiation and integration using MATLAB.
6. Solution of linear and non-linear differential equations.
7. Matrix factorization.
8. Frequency response for a spring-mass system; simulation of the oscillations
9. Stability analysis using Root locus, Bode plot, Nyquist plot and Polar plot techniques.
10. Simulate a bomb drop from an aircraft on a moving tank in pure pursuit motion.
11. Develop a straight and level flight simulation program using MATLAB
12. Simulate aircraft Take-off and Landing with trajectory tracing
13. Simulation of Hoffmann transfer
14. Simulation of velocity calculations for orbit maneuvering
15. Simulation of time period calculations for orbital motion

SEMESTER/YEAR : VI SEM / III YEAR
COURSE CODE : 16AS374
TITLE OF THE COURSE : MODEL BASED SYSTEM ENGINEERING
L: T/A: P: C : 01 :00 : 03 :00: 2.5

Course Objectives:

1. Student uses the knowledge and information gained in the course to expand and improve the application of model-based systems engineering in their field.

2. Student implements model-based systems engineering practices in their field that result in higher levels of value and satisfaction with engineered systems.

3. Student pursues further in-depth education and training in systems engineering

Course Outcomes:

1. Demonstrate analysis of systems using model-based systems engineering approaches that lead to better and increased performance of systems.

2. Describe the processes, methods, and practices of model-based systems engineering.

Model based system Engineering sessions: What is Landing Gear & it's function, Types of Landing Gear, Different parts of a Modern Landing Gear, Different parts of a Modern Landing Gear Shock Strut (3 hrs)

Assessment 1
Steering System, Brakes, Uplock & Downlock, Retraction & Extension, Emergency lowering of Landing Gear (4 hrs)
Assessment 2
Introduction to MBSE Process LG Design Process Requirement Management Theory, Requirement Management Lab, Functional Architecture, Mapping Requirements and Functional Components, practice sessions. (4 hrs) **Assessment 3**
Introduction to Mathematical modeling & Design of a DC motor, LG Detail Design Process Practice session, Logical Architecture Definition, Physical CAD Integration, Mapping Functional and Logical Components, Test Case Validation and Impact Analysis (18hrs) **Assessment 4**
Final Practice session, End Examination (theory & lab). (8hrs)

VII SEM

YEAR	**:**	**VII / IV**
COURSE CODE	**:**	**16AS401**
TITLE OF THE COURSE	**:**	**Avionics**
L: T: P: S/P: C	**:**	**03:00: 00:02: 04**

COURSE OBJECTIVES:

This course will enable students to:

1. To understand analyze Avionics System Requirements
2. To understand evolution of Flight Deck Design
3. To understand Federated and Integrated Avionics System Architectures involving MAU, LRMs and various digital Data bus networks.
4. To understand system assessment methods

COURSE OUTCOMES:

Upon successful completion of this course, the students:

1. To apply System requirement analysis methods for decomposition of functions among systems and sub systems
2. To build message structures using data bus concepts and to evolve conceptual avionics system architectures
3. To evolve avionics test bench architecture
4. To appreciate importance of HFE in Flight Deck Design and automation

Module 1 8 Hours

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 8 Hours

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 **8 Hours**

Electronic Flight Instrument Systems: Display -units, presentation, failure, and annunciation. Display of air data. Introduction to Avionics Sub Systems and Electronic Circuits: Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.

Module 4 **8 Hours**

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 **8 Hours**

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.

Text Books:

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

Program Elective Courses

Program Elective 3	Program Elective 4
1. Helicopter Dynamics 2. Aircraft Design 3. Rockets & Missiles 4. Unmanned Aircraft Systems & E-Mobility	1. Optimization Techniques 2. Nano Satellites 3. Introduction to Artificial Intelligence and Machine Learning 4. Aircraft Maintenance, Overhaul and Repair

SEMESTER/YEAR	**:**	**VII / IV**
COURSE CODE	**:**	**16AS403**
TITLE OF THE COURSE	**:**	**Helicopter Dynamics**
L: T: P: S/P : C	**:**	**03 :01 : 00 :00 : 04**

COURSE OBJECTIVES:

This course will enable students to:

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

COURSE OUTCOMES:

Upon successful completion of this course, the students:

1. Apply the basic concepts of helicopter dynamics.
2. Compute the critical speed by using various methods.
3. Distinguish the turbo rotor system stability by using transfer matrix and finite element formulations.

Module -1 **8Hours**

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 in hovering and forward flight. Rotating blade motion, Types of rotors

Module -2 **8Hours**

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. 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: **8Hours**

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 **8Hours**

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.

Module -5 **8Hours**

Standards and Specifications: Scope of requirements. General and operational requirements, Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces, 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

Text Books:

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

Reference Books:

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

SEMESTER/YEAR	**:**	**VII / I V**
COURSE CODE	**:**	**16AS404**
TITLE OF THE COURSE	**:**	**Aircraft Design**
L: T: P: S/P : C	**:**	**03 :00 : 00 :00 : 03**

COURSE OBJECTIVES

This course will enable students to

1. This course deals with Conceptual designs of aerospace vehicles, components, missions, or systems that incorporate realistic constraints/applicable engineering standards.
2. Students who successfully complete the course will demonstrate the outcomes by accomplishing the conceptual design of an aircraft

COURSE OUTCOMES

Upon successful completion of this course, the students:

1. Develop the ability to synthesize basic engineering science to accomplish a mission-driven design of an aircraft, including:
2. Perform conceptual airplane and propulsion sizing estimates to meet specified operational and performance requirements
3. Develop proficiency in and an appreciation for performing trade studies to optimize aircraft conceptual design.

Module 1 **8 Hours**

Overview of Design Process:

Introduction, Typical requirements for a civil transport and a military fighter aircraft, Phases of design, Aircraft conceptual design process, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation, Trade studies.

Airfoil Selection: Airfoil geometry, Airfoil lift and drag, Airfoil families, Airfoil design, Airfoil lift coefficient, Airfoil thickness, Camber, Stall, Reynolds number effects

Module 2 **9 Hours**

Geometry: Wing geometry, Aspect ratio, Sweep, Taper ratio, Twist, Incidence, Dihedral, Wing vertical location of wings, Wing tips, Biplane wings, Tail geometry and arrangement

Thrust to Weight Ratio & Wing Loading Thrust to weight definitions, Power loading, Statistical estimate of T/W. Thrust matching, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance.

Module 3 **8 Hours**

Initial Sizing: Rubber engine sizing, Fixed engine sizing, Geometry sizing – Fuselage, Wing, Tail volume coefficient and Control surface sizing,

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

Module 4 **8 Hours**

Aerodynamics & Propulsion: A brief overview of aerodynamic coefficients and forces, Types of propulsion systems, Jet engine thrust considerations, Thrust-drag book keeping, Installed thrust methodology, Piston engine performance – propeller performance and piston-prop thrust correction, Turboprop performance

MODULE 5 **7 Hours**

Sizing calculation using spread sheet, Design using CAD software. Software available for aircraft design (OpenVSP)

Text Books:

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

Reference Books:

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

SEMESTER/YEAR	**:**	**VII SEM / IV**
COURSE CODE	**:**	**16AS405**
TITLE OF THE COURSE	**:**	**Rockets & Missiles**
L: T: P: S/P: C	**:**	**03:00: 00:00: 03**

COURSE OBJECTIVES:

This course will enable students to

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

COURSE OUTCOMES:

Upon successful completion of this course, the students:

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

Module 1 **8 Hours**

Introduction to Rocket Systems

Types of Ignition System in rockets and types of Igniters – Igniter Design. Consideration of liquid Rocket Combustion Chamber, Injector Propellant Feed Lines. Propellant Tanks Outlet and Helium Pressurized and Turbine feed Systems–Propellant Slash and Propellant Hammer–Elimination of Geysering Effect in Missiles–Combustion System of Solid Rockets, Selection of Materials –Special Requirements of Materials to Perform under Adverse Conditions.

Module 2 **8 Hours**

Aerodynamics of Rockets and Missiles

Airframe Components of Rockets and Missiles – Forces Acting on a Missile While Passing Through Atmosphere– methods of Describing Aerodynamic Forces and Moments – Lateral Aerodynamic Moment – Lateral Damping Moment and Longitudinal Moment of a Rocket – lift and Drag Forces – Drag Estimation – Body Upwash and Downwash in Missiles.

Module 3 **8 Hours**

Motion In Space and Gravitational Field

One Dimensional and Two Dimensional rocket Motions in Free Space and Homogeneous Gravitational Fields–description of Vertical, Inclined and Gravity Turn Trajectories– Determination of range and Altitude Simple Approximations to Burnout Velocity.

Module 4 **8 Hours**

Staging and Control

Rocket Vector Control – Methods – Thrust determination – SITVC – Multistaging of rockets – Vehicle Optimization – Stage Separation Dynamics – Separation Techniques.

Module 5 **7 hours**

SOFTWARE

Hands on experience on software modules like Rocket Modeler, Kite Modeler, Rocket Simulation

TEXT BOOKS

1. Sutton G. P, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 1993.
2. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W., Freeman & Co. Ltd., London, 1982.

REFERENCES

1. Mathur, M., and Sharma, R.P., "Gas Turbines and Jet and Rocket Propulsion", Standard Publishers, New Delhi 1998.
2. Parker, E. R., "Materials for Missiles and Spacecraft", McGraw-Hill Book Co. Inc., 1982.
3. M. J. Zucrow, "Missile Propulsion", John Wiley & sons.
4. H. S. Mukunda, "Understanding Aerospace Chemical Propulsion", Interline Publishing Company Bangalore.

SEMESTER/YEAR : VII / IV

COURSE CODE :16AS406
TITLE OF THE COURSE : Unmanned Aircraft Systems & E- Mobility
L: T: P: S/P: C : 03:00: 00:00: 03

COURSE OBJECTIVES:

This course will enable students to

1. To understand roles and responsibilities for UAVs.
2. To identify and define aircraft systems and navigation
3. To understand the basics of electric vehicles, their architecture and modeling.

COURSE OUTCOMES:

Upon successful completion of this course, the students:

1. Describe different phases of design of UAVs.
2. Describe the basic principles of UAS operation requirements and develop concept operation
3. Describe various E-Vehicle management systems and its simulations.

Module 1 **10 Hours**

Introduction to Unmanned Aircraft Systems (UAS). The Beginning The Need for Effective Control The First Modern Unmanned Aircraft; The Target Drone Some Applications of UAS, The Systemic Basis of UAS System Composition Basic Technology Control Methods. Classification of UAS Long-endurance, Long-range Role Aircraft Medium-range, Tactical Aircraft Close-range/Battlefield Aircraft; MUAV Types MAV and NAV Types, UCAV Novel Hybrid Aircraft, Configurations Research UAV

Module 2 **10 Hours**

Introduction to Design and Selection of the System Conceptual Phase Preliminary Design Detail Design Selection of the System Aerodynamics and Airframe Configurations Lift-induced Drag Parasitic Drag Rotary-wing Aerodynamics Response to Air Turbulence Airframe Configurations
Transportation: Micro-UAV VTOL Close-range Systems HTOL Close-range Systems Medium-range Systems MALE and HALE Systems

Module 3 **10 Hours**

THE DEVELOPMENT OF UAV SYSTEMS

Introduction to System Development and Certification System Development Certification Establishing Reliability System Ground Testing UAV Component Testing UAV Sub-assembly and Sub-system Testing Complete UAV Control Station Testing Catapult Launch System Tests Documentation System In-flight Testing Test Sites Preparation for In-flight Testing In-flight Testing System Certification

Module 4 **10 Hours**

Electro mobility and the Environment

A Brief History of the Electric Powertrain, Energy Sources for Propulsion and Emissions, The Advent of Regulations, Drive Cycles, BEV Fuel Consumption, Range, and mpge, Carbon Emissions for Conventional and Electric Powertrains, An Overview of Conventional, Battery, Hybrid, and Fuel Cell Electric Systems, A Comparison of Automotive and Other Transportation Technologies.

Vehicle Dynamics: Vehicle Load Forces, Vehicle Acceleration, Simple Drive Cycle for Vehicle Comparisons

Module 5 **10 Hours**

Battery Management & EV Simulation

Batteries Types and Battery Pack, Lifetime and Sizing Considerations, Basic Requirements for Charging System, Charging Standards and Technologies, BMS Definition, Li-Ion Cells, Li-Ion BMSs, Li-Ion Batteries,BMS Functions: Measurement: Voltage, Temperature, Current.

EV Simulations: system level simulation, EV simulator, simulator modules, performance evaluation, system optimization.

Text books:

1.Reg Austin, Unmanned Aircraft systems UAVs Design, Development and Deployment, A John Wiley & Sons,Ltd.,2010.

2. Douglas M.Marshall et al., Introduction to unmanned Aircraft systems, second edition Taylor & Francis, 2016.

3. Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, 1st Edition, 2018, Wiley, ISBN 9781119063667.

Reference Books:

1. Jay Gundlach, Civil and commercial Unmanned Aircraft Systems, AIAA Education Services, 2016

2. Battery Management system for large Lithium Battery Packs, Davide Andrea, 1st Edition, 2010, ARTECH HOUSE, ISBN-13 978-1-60807-104-3

3. Hybrid Vehicles from Components to System, F. BADIN, Ed, 1st Edition, 2013, Editions Technip, Paris, ISBN 978-2-7108-0994-4.

4. Modern Electric Vehicle Technology C.C. Chan and K.T. Chau, 1st Edition, 2001, Oxford university press, ISBN 0 19 8504160.

SEMESTER/YEAR : VII / IV
COURSE CODE : 16AS407
TITLE OF THE COURSE : Optimization Techniques

L: T: P: S/P: C : 03:00: 00:00: 03

COURSE OBJECTIVES:

This course will enable students to

1. To introduce Optimization techniques and their applications
2. To formulate Optimization problems and selecting techniques to solve them
3. To study and understand the Un-constrained and Constrained techniques

COURSE OUTCOMES:

Upon successful completion of this course, the students:

1. Formulate the optimization problems and use suitable algorithm to solve Linear and Non-Linear Programming
2. Formulate Un-constrained and constrained optimization models and solve them using appropriate techniques

MODULE 1 - Introduction to Optimization 7Hours

Engineering application of optimization, statement of an optimization problem with example for minimum weight and optimum cost consideration, classification of optimization problems and techniques, Single variable optimization, multi-variable optimization with equality and inequality constraints and without constraints.

MODULE 2 - Formulation of optimization problems 7Hours

Continuous functions - Discrete functions - Unimodal functions - Convex and concave functions. Necessary and sufficient conditions for optimum of unconstrained functions Numerical methods for unconstrained functions - One-dimensional search - Gradient-free search with fixed step size.

MODULE 3 - Linear & Non-Linear Programming 10Hours

Linear: Introduction, standard form of the problem, Geometry, basic terminology Techniques of linear programming: Simplex method, Revised simplex method: Duality in linear programming, decomposition principle, post-optimality analysis.

Non-Linear: Introduction, elimination methods: various search methods- Fibonacci method and golden section method Interpolation Method-Quadratic and cubic interpolation methods, Direct root method.

MODULE 4 - Introduction to Unconstrained Optimization 8Hours

Introduction; Standard form of the problem and basic terminology; Direct search method- Simplex

method, Random search method, Univariate and pattern search method Indirect search method- Steepest Descent (Cauchy)method, Conjugate gradient method, Newton's method, Application to engineering problems.

MODULE 5- Introduction to Constrained Optimization 8Hours

Standard form of the problem and basic terminology; Direct method: Sequential Linear Programming; Generalized Reduced gradient method, Methods of feasible direction Indirect method: Penalty function method Interior and exterior penalty function method, Convex programming problem, Check for convergence Application to engineering problems.

Case Study: Genetic Algorithm based Optimization, Neural network based optimization.

Text Books

1. S.S.Rao, Engineering Optimisation- Theory and Practice, New Age International. 4th Edition.
2. G. Zapfel, R. Barune and M. Bogl, Metaheuristic search concepts: A tutorial with applications to production and logistics, Springer.2010

Reference Books

1. Gass S. I., Introduction to Linear Programming, Tata McGraw Hill.
2. Reeves C., Modern heuristic techniques for combinatorial problems, Orient Longman.
3. Goldberg, Genetic algorithms in Search, optimization and Machine Learning, Addison Wesley.
4. K. Deb, Optimization for engineering design – algorithms and examples, Prentice Hall of India.
5. Gallagher and O.C Zeinkiewicz, Optimum Structural Design Theory & Applications, John Wiley

SEMESTER/YEAR	**:**	**VII / IV**
COURSE CODE	**:**	**16AS408**
TITLE OF THE COURSE	**:**	**Satellite Technologies**
L: T: P: S/P: C	**:**	**03:00: 00:00: 03**

COURSE OBJECTIVES:

This course will enable students to

1. Understand the function of spacecraft subsystems.
2. Apply orbital mechanics formula and tools to spacecraft mission design.
3. Select appropriate launch systems and understand their affect on satellite and payload design and performance

COURSE OUTCOMES:

Upon successful completion of this course, the students

1. Evaluate spacecraft subsystem performance and trades
2. Estimate space system costs
3. Trade subsystem performance requirements to optimize higher-level system performance, cost, or weight

Module 1: Mission planning analysis and design **8 hours**

The space era, Nano satellite, Nano satellite-Evolution, Disruptions, global economics, future scenario. Orbital elements, types of orbits-LEO, SSO, MEO, GEO, Mission definition, Mission objectives, Mission analysis, mission operations .Mission control software Basic concepts of flight dynamics.

Module 2: Payload options for Nano satellite **8 hours**

Types of payload for a nanosatellite, design considerations for payloads, Earth observation payloads-optical camera, infra-red camera, spectrometers. Communication payloads in a Nanosatellite-Store and forward system, Ionospheric effects, AIS, laser communications, scientific payloads.

Module 3: Nanosatellite structure & Thermal Control systems **8 Hours**

Types of structure design, Building structure, CubeSat Structure, Material for structure, structure analysis, testing of structure.

Thermal systems: Satellite working environment, design and analysis, implementation of TCS, types of thermal control-Active and passive thermal controls, testing of nanosatellite for verification of TCS.

Module 4: Communication systems and Digital electronics 8 Hours

OBC hardware and software, telemetry-TM data acquisition, on board time, on board data storage, tele command- Code selection command format, Attitude control electronics Space segment RF communication, ground segment-Earth station, optical and laser communication.

Module 5: Product Assurance 8 Hours

Environment conditions a satellite undergo Product assurance and quality assurance, Reliability analysis, Reliability standards and specifications, Reliability prediction, Product assurance for a nanosatellite, software quality assurance.

Software's

CubeSat Simulation Library, Introduction to STK software

Text Books

1. "Quintessence of Nano-Satellite technology", Planet Aerospace India, Notion Press, ISBN: 978-1-64951-662-6, 2020.

Reference Books

1. Nithin Sivadas,Akshay Gulati, "A Nanosatellite Mission to study charged particle precipitation from van Allen Radiation Belts caused due to Sesimo-Electromagnetic Emissions", Indian Institute of technology Madras.
2. NASA Ames Launching Nanosatellites, Science Experiments on SpaceX Rocket, April 10, 2014.
3. Communications"-Dennis Roddy Publisher: Tata McGraw Hill Education Pvt Ltd, Delhi.

SEMESTER/YEAR : VII / IV

COURSE CODE :16AS409

TITLE OF THE COURSE : Introduction to Artificial Intelligence & Machine learning
L: T: P: S/P: C : 03:00: 00:00: 03

COURSE OBJECTIVES:

This course will enable students to

1. The course aims to provide a foundation in artificial intelligence techniques for planning, with an overview of the wide spectrum of different problems and approaches, including their underlying theory and their applications.

COURSE OUTCOMES:

Upon successful completion of this course, the students

1. Understanding fundamental of the history of artificial intelligence (AI) and its foundations.
2. Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation, and learning
3. Demonstrate awareness and a fundamental understanding of various applications of AI techniques in intelligent agents, expert systems, artificial neural networks and other machine learning models.

Module 1 **8 hours**

Introduction to Data Science and AI & ML, Data Science, AI & ML, Essential Concepts in AI and ML Data Understanding, Representation and Visualisation

Module 2: **8 hours**

Machine Learning: Linear Methods, Linear Regression, Multiple Linear Regression, Non-Linear Regression, Clustering, Forecasting models, Perceptron and Neural Network, Decision Trees, Support Vector Machines

Module 3: **8 hours**

Probabilistic Models, Dynamic programming and Reinforcement Programming, Evolutionary

Algorithms, Time Series Models, Deep Learning, Emerging Trends in ML, Unsupervised Learning

Module 4 **8 hours**

Foundations for AI, AI Basics, AI Classification, Supervised Learning, Feature Engineering Regression, Model Selection, Model Performance, Ranking

Module 5 **8 hours**

Introduction to ML with R and using Python, Python and R for Artificial Intelligence, Machine Learning, and Data Science, AI/ML in aerospace industry

Text Books

1. Machine Learning and Artificial Intelligence, Ameet V Joshi, Springer, Microsoft(USA),Redmond, ISBN 978-3-030-26621-9
2. Artificial Intelligence and Machine Learning fundamentals, Zsolt Nagy,Pact Publishing, UK, ISBN 978-1-78980-165-1

Reference Books

1. Artificial Intelligence and Machine Learning, Vinod Chandra SS , PHI, ISBN 978-81-203-4934-6
2. Basics of Artificial Intelligence and Machine Learning, Dheeraj Mehrotra,Notion Press, eISBN 978-1-64587-283-2

SEMESTER/YEAR : VII SEM / IV COURSE
CODE :16AS410
TITLE OF THE COURSE : Aircraft Maintenance, Overhaul and Repair
L: T: P: S/P: C : 03:00: 00:00: 03

COURSE OBJECTIVES:

This course will enable students to

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

COURSE OUTCOMES:

Upon successful completion of this course, the students

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

Module -1 **8 Hours**

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, Powerplant, Avionics courses.

Module -2 **8 Hours**

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), calibration manual, Directorate General of Civil Aviation (DGCA)

Module -3 **8 Hours**

Aircraft Management Maintenance

Structure, Role of aviation management, Line supervisory management, Management areas of concern in airlines, Manager of overhaul shops, Line maintenance control center flight line (preflight & post flight), Aircraft Logbook, daily check on major components of aircraft depending on airframe (flying) hours or calendar life, Maintenance crew skill requirements. First Flight Servicing (FFS), Turn Round Servicing (TRS), Last Flight Servicing (LFS), Types of maintenance bases

Module -4 **9 Hours**

Hangar 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 and ground handling 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, spares management, approved bonded stores for airborne items.

Module -5 **7 Hours**

Maintenance Safety &Trouble shooting

FOD, Safety regulations, Role of ATC. Tarmac discipline and management, 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, repeated snags, rectifications, modifications on aircraft and release of mod leaflets, Knowledge of malfunctions.

Text Books:

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

Reference Books:

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

SEMESTER/YEAR : VII/IV

COURSE CODE : 16AS402

TITLE OF THE COURSE : LAW FOR ENGINEERS

L: T/A: P: C : 2 : 0 : 2 : 3

COURSE OBJECTIVES

The students will be able to

1. Apply the knowledge of the constitutional literacy to become aware of the fundamental rights and duties in their role as Engineers
2. Understanding of ethical and legal aspects of advertising, consumer problems and their redressal mechanism related to product and service standards.
3. Demonstrate an advanced and integrated understanding of the nature and extent of the corporate entity principle and to understand how this principle applies to corporate groups
4. Critically evaluate the extent and application of the Corporate Law.

COURSE OUTCOMES

After completing the course, the students will be able to

1. Understand process of ethical and moral analysis in decision making scenarios and inculcate ethical behavior as a trait for professional development.
2. Apply the knowledge to solve practical problems with regard to personal issues & business enterprises.
3. Identify the conflict management in legal perspective and judicial systems pertaining to professional environment; strengthen the ability to contribute to the resolution of human rights & Ragging issues and problems through investigative and analytical skills.

Module I: Introduction 8 Hours

Introduction to Indian legal system, Review of Constitution of India, Sources of Law and Judicial system.

Contracts and its Elements: Employment contracts, Contract Interpretation, service contract , Contract of Indemnity, Law of Agency, Employment Agreement

Module II : Legal documentation **8 Hours**

Legal documentation: Drafting of legal documents including Non-Disclosure Agreements (NDA) , Request for proposal (RFP), Collaboration Agreement , Joint Venture Agreements, Tendering and sub-contracting

Module III: Property Rules, Trademarks & Copy Rights **10 Hours**

Intellectual Property Rules (IPR) Overview, Trademarks, Copy Rights, Patents with special emphasis in Biotechnology Inventions, Software Circuits and Design, Protection in Foreign Countries

Module IV: Introduction to Labour and Environmental Laws **8 Hours**

Labour Laws: Provident Fund, ESIC, Gratuity, Bonus, Perquisites, Contract labour, Health, Safety and welfare of construction workers,

Introduction to Environmental Law, Concept of Law & Policy , Environment and Governance ,Sustainable Development and Environment , Understanding Climate Change and its processes – CDP, CDMs and Carbon Off Setting, Overview of International Environmental Laws, Introduction to Environment and IPR

Module V: Cyber Laws & Taxation **10 Hours**

Cyber Laws , E-Commerce and E-Governance, Taxation: Income Tax, Service Tax, VAT, Excise Duty, RTI Act.

Text books

1. V.S. Datey, Indirect Taxes: Law and Practice, Taxmann Publications (P) Ltd, Latest Edition Publications (P) Ltd, latest Edition.
2. S.C. Srivastava, Industrial Relations and Labour Laws, Vikas Publishing House Pvt. Ltd.
3. Joseph Minatiur, Indian Legal System, Indian Law Institute, New Delhi.

Reference books

1. Kamith Seth, Computer Internet and New Technology Laws, LexisNexis, First Edition 2013.
2. Prafulla C Pant, The Arbitration and Conciliations Act, 1996, ButterworthsIndia, New Delhi.
3. J. Beatson, Anson's Law of Contract, Oxford University Press

SEMESTER /YEAR : VII/IV

COURSE CODE : 16AS471

TITLE OF THE COURSE : AI & ML Lab

L: T/A:P: C : 0 : 0 : 3 : 1

COURSE OBJECTIVES:

This course will enable students to

1. This course aims to provide a foundation in artificial intelligence techniques for planning, with an overview of the wide spectrum of aerospace problems

COURSE OUTCOMES:

At the end of this course, student is able to

1. Write program in Python for general purpose
2. Appreciate the need for data cleaning, data visualization
3. Familiar with Machine learning algorithms available in Python.
4. Familiar with data sets related to aero and space applications

LIST OF EXPERIMENTS:

1. Applications of AI&ML in Aerospace Engineering
2. Introduction to data science, machine learning and Python
3. Introduction to case studies (Engine Health Monitoring, satellite data, etc.) and get the datasets from the open literature
4. Work on data cleaning, data visualization and data analysis (statistical quantities)
5. Introduction to machine learning methods (Supervised/Un-supervised and Reinforcement Learning)
6. Very quick introduction to machine learning algorithms (Linear Regression. Logistic Regression. Decision Tree. SVM, Naive Bayes. kNN, K-Means, Random Forest.)
7. Dividing the available data into training and testing data
8. Discussion on trend analysis and applying various machine learning algorithms available in python
9. Discussion on openly available data sets for aerospace and other industries

VIII SEMESTER

SEMESTER/YEAR	**:**	**VIII / IV COURSE**
CODE	**:**	**16AS412**
TITLE OF THE COURSE	**:**	**Aerospace Technical Publications**
L: T: P: S/P: C	**:**	**03:00: 00:00: 03**

SEMESTER/YEAR : VIII SEM / IV
COURSE CODE : 16AS413
TITLE OF THE COURSE : NPTEL course on Rockets & Propulsion
L: T: P: S/P: C : 03:00: 00:00: 03