



SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited "A++" Grade by NAAC | 12B Status by UGC | Approved by AICTE

www.sathyabama.ac.in

SCHOOL OF MECHANICAL ENGINEERING

DEPARTMENT OF AERONAUTICAL ENGINEERING

1.1.3 Courses having focus on employability/ entrepreneurship/skill development

S. No.	Course Code	Name of the Course	Page No.
1	SAEA1401	Aircraft Propulsion	2
2	SAEA1402	Aircraft Structures	3
3	SAEA1403	Low Speed Aerodynamics	4
4	SAEA1501	Aircraft Performance	5
5	SAEA1502	Aerospace Propulsion	6
6	SAEA1503	Computational fluid dynamics for Aerospace applications	7
7	SAEA1504	Finite Element Methods for Aircraft Structures	8
8	SAEA1505	High Speed Aerodynamics	9
9	SAEA3017	Manned space mission	10
10	SAEA1601	Aircraft Stability and Control	11
11	SAEA1602	Theory of Vibration and Aero Elasticity	12
12	SAEA3016	Flight vehicles Guidance and Control	13
13	SAEA2603	Aircraft Design Project Lab	14
14	SAEA1702	Unmanned Aerial Vehicle Design	15
15	SAEA4002	Fundamentals of Aerospace Technology	16
16	SAEA1201	Aircraft Materials	17
17	SAEA1303	Aircraft Systems and Instruments	18
18	SAEA1304	Introduction to Aerodynamics	19
19	SAEA1305	Introduction to Aircraft Structures	20
20	SAEA2301	Aircraft Structures Lab - I	21
21	SAEA2401	Aerodynamics Lab	22
22	SAEA2402	Aircraft Structures Labs - II	23
23	SAEA3014	Boundary layer theory	24
24	SAEA3015	High temperature Materials	25
25	SAEA3019	Orbital Mechanics	26

SAEA1401	AIRCRAFT PROPULSION	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To introduce the concepts of applying Aero thermodynamics to air breathing propulsion.
- To familiarize the student's ability to analyze the concepts of compressor.
- To understand the basics of Axial Turbine.
- To understand the basics of Ramjet and Scramjet.

UNIT 1 THERMODYNAMICS OF AIR BREATHING PROPULSION**9 Hrs.**

History and classifications of Aero engines, Working of gas turbine engine – Thrust equation – Factors affecting thrust – Engine performance parameters – Efficiency, Specific fuel consumption, Methods of thrust augmentation – The propeller, turboprop, turbofan and turbojet engines characteristics.

UNIT 2 INLETS, COMBUSTION CHAMBER AND NOZZLES**9 Hrs.**

Introduction-Subsonic inlets-Supersonic inlets-Modes of Inlet operation- Gas turbine combustors-Types of combustion chamber-Fuel injector- Flame Tube cooling-Flame Stabilization-Flame holders- Theory of flow in isentropic nozzles – Losses in nozzles –Nozzle efficiency—nozzle choking –Over expanded and under expanded nozzles – Ejector and variable area nozzles.

UNIT 3 AIR COMPRESSOR**9 Hrs.**

Compressor and its classification- Centrifugal compressor - Work and compression ratio -Performance characteristics- Centrifugal compressor staging- Axial compressor-Work and compression ratio- Degree of reaction- Characteristic performance of a single stage axial compressor- Characteristic performance of a multistage axial compressor- Cascading of axial compressor-Compressor efficiency.

UNIT 4 AXIAL TURBINES**9 Hrs.**

Axial turbine stage -Velocity triangles and Power output - Elementary theory - Vortex theory- Limiting Factors of gas turbine design-Turbine performance- Turbine Blade cooling- Axial flow Turbine and compressor matching.

UNIT 5 RAMJET AND SCRAMJET**9 Hrs.**

Operating principle of RAMJET engine- RAMJET with afterburner- RAMJET performance- SCRAMJET working principle- Problems faced in supersonic combustion.

Max 45 Hrs.**COURSE OUTCOME**

On completion of the course, student will be able to

- CO1 - Understand the working principles of gas turbine.
- CO2 - Comprehend the sound foundation in the design principles of inlets, combustion chambers, nozzles used in aircraft engines.
- CO3 - Learn the operation of compressors in aircraft engines.
- CO4 - Understand the concept of turbines in gas turbine propulsion systems.
- CO5 - Understand the principle and performance of ramjet and scramjet propulsion.
- CO6 - Applying the importance of Propulsion to Aircraft system.

TEXT / REFERENCE BOOKS

1. Philip Hill and Carl Peterson, "Mechanics and thermodynamics of propulsion", Pearson India, second edition 2010.
2. V.Ganesan., "Gas Turbines", Tata McGraw-Hill Education, third edition, 2010.
3. Cohen.H, Rogers.G.F.C. and Saravanamuttoo.H.I.H, "Gas turbine theory". Pearson education, fifth edition,2001.
4. Rathakrishnan E., "Fundamentals of Engineering Thermodynamics", Prentice-Hall India, 2012.
5. Saeed Farokhi, "Aircraft Propulsion", John Wiley & Sons, Inc ., 2009.
6. Rolls Royce Jet Engine – 5thEdition – 1996.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks:100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks**

Employability

SAEA1402	AIRCRAFT STRUCTURES	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To provide the students various methods for analysis of aircraft wings and fuselage.
- To provide the behaviour of major aircraft structural components.

UNIT 1 STATICALLY DETERMINATE AND INDETERMINATE STRUCTURE**9 Hrs.**

Truss: Analysis of plane truss–Method of joints–3D Truss. - Load transmission in multiple span beam–Clapeyron's Three Moment Equation.

UNIT 2 ENERGY METHODS**9 Hrs.**

Strain Energy due to axial, bending and Tensional loads–Castigliano's theorem–Maxwell's Reciprocal theorem, Unit load method, The principle of virtual work– application to beams, trusses, -redundant center.

UNIT 3 UNSYMMETRICAL BENDING**9 Hrs.**

Bending stresses in beams of unsymmetrical sections– Bending of symmetric sections with skew loads.

UNIT 4 SHEAR FLOW IN OPEN AND CLOSED SECTIONS**9 Hrs.**

Concept of shear flow, shear centre, Elastic axis. With one axis of symmetry, with wall effective and ineffective in bending, unsymmetrical beam sections. Bredt–Batho formula, Shear flow in single & multi cell structure under torsion.

UNIT 5 STRESS ANALYSIS IN WING AND FUSELAGE**9 Hrs.**

Structural lay out of the Airplane and components, loads acting on major components such as wing, fuselage, tails, landing gear etc., Concept of allowable stress and margin of safety. Procedure–Shear and bending moment distribution for semi cantilever and other types of wings and fuselage, thin webbed beam. With parallel and nonparallel flanges, Shear resistant web beams, Tension field web beams(Wagner's).

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

CO1 - Analysis of plane truss and load transmission techniques in multiple span beam.

CO2 - Analysis of various loads in beams and trusses and strain energy.

CO3 - Analysis of Bending stresses in beams of unsymmetrical sections.

CO4 - Analysis of shear flow, shear center in open and closed sections.

CO5 - Analysis of Structural lay out of the Airplane and components.

CO6 - Analysis of loads acting on major components such as wing, fuselage, tails, landing gear.

TEXT / REFERENCE BOOKS

1. Megson, T.M.G., "Aircraft Structures for Engineering Students", Edward Arnold, 2012.
2. Bruhn. E.H. "Analysis and Design of Flight vehicles Structures", Tri– stateoff set Company, USA, 2015.
3. Millard V.Barton, "Fundamentals of Aircraft Structures " Prentice Hall, 2012.
4. Timoshenko, S., "Strength of Materials", Vol. I and II, Princeton D. Von Nostrand Co, 2012.
5. Donaldson, B.K., "Analysis of Aircraft Structures– An Introduction", McGraw-Hill, 2011.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.**

PART A: 10 Question of 2 marks each – No choice

20 Marks

PART B: 2 Questions from each unit of internal choice, each carrying 16 marks

80 Marks
 **Employability**

SAEA1403	LOW SPEED AERODYNAMICS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- 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.
- To introduce the basics of viscous flow.

UNIT 1 REVIEW OF BASIC AERODYNAMICS**9 Hrs.**

Atmosphere- Air speeds- Aerodynamic definitions Types of Drag- General Aerodynamic characteristics of airfoil sections- Complex potential-Singularities-Equations of Vortex-doublet and Rankine oval - Lift and Drag on cylinder and Aero foil.

UNIT 2 LOW SPEED FLOW**9 Hrs.**

Models of the fluid: control volumes and fluid elements. Continuity, Momentum and energy equations. Substantial derivative, incompressible Bernoulli's equation.

UNIT 3 AIRFOIL AND CONFORMAL TRANSFORMATION**9 Hrs.**

Airfoils Nomenclature and NACA series, Airfoil Characteristics, Vortex sheet, Kelvin Circulation theorem Thin aerofoil theory and its applications. Joukowski transformation and its application to fluid flow problems.

UNIT 4 WING THEORY**9 Hrs.**

Introduction to Finite wing, Downwash and Induced Drag, Biot -Savart law and Helmholtz's theorems, Horse shoe vortex, Prandtl's Classical Lifting line theory and its limitations.

UNIT 5 VISCOUS FLOW**9 Hrs.**

Derivation of Navier-Stokes equation for two-dimensional flows, boundary layer approximations, laminar boundary equations and boundary conditions, Blasius solution, qualitative features of boundary layer flow under pressure gradients, Integral method, aspects of transition to turbulence, turbulent boundary layer properties over a flat plate at low speeds. Separation of flow over bodies stream lined and bluff bodies, Lift and Drag on cylinder and Aero foil.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Apply aerodynamics concepts.
- CO2 - Develops mathematical modelling ability.
- CO3 - Differentiate between ideal and real flows.
- CO4 - Model flow over wing.
- CO5 - Understand the real time viscous flow.
- CO6 - Understand the Boundary Layer behaviour.

TEXT / REFERENCE BOOKS

1. Aerodynamics for. Engineering Students. Sixth Edition. E.L. Houghton. P.W. Carpenter. Steven H. Collicott. Daniel T. Valentine, 2013 Elsevier, Ltd.
2. Bertin, John J., Aerodynamics for Engineers, Pearson Education Inc., 2002.
3. John J. Bertin, Russell M. Cummings, "Aerodynamics for Engineering students", Sixth Edition, Pearson, 2013.
4. Anderson J.D., "Fundamentals of Aerodynamics", Sixth Edition, McGraw Hill Book Co., New York, 2017.
5. Schlichting H., "Boundary layer theory", Seventh Edition, McGraw Hill, New York 2014.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks**

Employability

SAEA1501	AIRCRAFT PERFORMANCE	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To evaluate the performance of air vehicles in real atmosphere versus standard atmosphere.
- To study the different forces acting on a vehicle in flight, drag, variation of thrust, performance during different conditions, and flight testing.
- To perform various testing methods to compare different aircraft performances.

UNIT 1 PREREQUISITES TO EVALUATE AIRCRAFT PERFORMANCE**9 Hrs.**

Properties of earth's atmosphere and standard atmosphere, Forces and moments acting on a flight vehicle - Equation of motion of a rigid flight vehicle- Different types of drag – estimation of parasite drag co-efficient by proper area method- Drag polar of vehicles from low speed to high speeds.

UNIT 2 ENGINE CHARACTERISTICS**9 Hrs.**

Variation of thrust, power with velocity and altitudes for air breathing engines – specific fuel consumption of piston engine and jet engine – ideal efficiency of engines- power plants for flight vehicles – limitations of power plants with Mach number and altitude.

UNIT 3 EVALUATION OF UN - ACCELERATED FLIGHT PERFORMANCE**9 Hrs.**

Airplane performance in steady level flight - Power available and power required curves. Maximum speed in level flight - Conditions for minimum drag and power required - steady climb descent and glide performance. Climb and Glide Hodograph, Range and Endurance.

UNIT 4 ACCELERATED AND MANOEUVERING FLIGHT PERFORMANCE**9 Hrs.**

Accelerated level flight - Climbing and gliding flight, Maximum rate of climb and steepest angle of climb, minimum rate of sink and shallowest angle of glide –Take off – Landing-Turning performance. Bank angle and load factor – limitations on turn - V-n diagram.

UNIT 5 FLIGHT TESTING METHODS TO EVALUATE PERFORMANCE**9 Hrs.**

Flight - testing: Altitude definitions, Speed definitions, Air speed, altitude and temperature measurements. Errors and calibration. Measurement of engine power, charts and corrections. Flight determination of drag polar.

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Understand the need for ISA.
- CO2 - Analyze the flight performance with variations of pressure and density with altitude.
- CO3 - Estimation of total drag and drag polar that influence the performance.
- CO4 - Analyze the performance in un-accelerated flight conditions.
- CO5 - Determination of speed limit, load limit, landing and takeoff distances of the aircraft.
- CO6 - Know different testing methods to evaluate aircraft performance.

TEXT / REFERENCE BOOKS

1. Perkins, C.D., and Hage, R.E., "Airplane Performance stability and Control", John Wiley & Son.,Inc, NY, 2011.
2. McCormick, W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, NY, 2010.
3. McCormick B. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, NY, 2011.
4. Babister, A.W., "Aircraft Stability and Response", Pergamon Press, 1980.
5. McCormick, B. W., "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, 1995.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks**

Employability

SAEA1502	AEROSPACE PROPULSION	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To introduce the concepts of applying Aero thermodynamics to non air breathing propulsion.
- To familiarize the student's ability to analyze the concepts of Advance Propulsion.
- To understand the basics of Solid Propellant, Liquid Propellant and Cryogenics.
- To understand the basics of Micro propellants.

UNIT 1 FUNDAMENTALS OF ROCKET PROPULSION**9 Hrs.**

History and evolution of rockets - Rocket principle and Rocket equation - Classification of rockets - Mass ratio of rocket- Rocket Nozzles - Classifications - Nozzle Performance - Nozzle area ratio - Mass flow rate Characteristic velocity - Thrust coefficient-Performance parameters and Efficiencies of rocket - Staging and Clustering.

UNIT 2 SOLID PROPELLANT ROCKET**9 Hrs.**

Hardware components and its functions - Mechanism of burning - Ignition system and igniter types- Propellant grain configuration and its applications - Burn rate - Factors influencing burn rates-Burn rate index for stable operation - Action time and burn time - Design of Solid Propellant rocket.

UNIT 3 LIQUID AND CROGENIC PROPELLANT ROCKET**9 Hrs.**

Classifications - Hardware components and its functions-Propellant feed systems and Turbo pump feed system - Injectors and types - Thrust chamber and its cooling-Cryogenic propulsion system, Special features of cryogenic systems. Thermo-physical Properties of Cryogenic Propellants; Geysering Phenomenon.

UNIT 4 ADVANCE PROPULSION TECHNIQUES**9 Hrs.**

Hybrid propellant rocket and gelled propellants - Electrical rockets - Electro-thermal, Electro-static and Electro-magnetic propulsion system- Arc-jet thruster - Ion thruster - Hall Effect Thruster - Magneto plasma dynamic thruster- Nuclear rockets - Solar sail.

UNIT 5 MICRO PROPULSION SYSTEM**9 Hrs.**

Recent Micro Spacecraft Developments; Micro propulsion Options; Primary Set of Micro propulsion Requirements; Chemical Propulsion Options; Review of Electric Propulsion Technologies for Micro and Nano- satellites; Emerging Technologies: MEMS and MEMS- Hybrid Propulsion System.

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Understand the working principles of non air breathing engine.
- CO2 - Comprehend the sound foundation in the design principles of solid propellants.
- CO3 - Learn the operation of Liquid and Cryogenic Propellant Rocket.
- CO4 - Understand the concept of Advance Propulsion Techniques.
- CO5 - Understand the principle and performance of. Micro propulsion system.
- CO6 - Applying the importance of Advance Propulsion in Aerospace.

TEXT / REFERENCE BOOKS

- George P. Sutton and Oscar Biblarz. "Rocket Propulsion Elements" 9th Edition, Wiley Publication, 2016.
- Ramamurthi.K: "Rocket propulsion" Macmillan Publishing Co, India. 1st Edition. 2010.
- Hill.P.G. and Peterson.C.R: "Mechanics and thermodynamics of propulsion" 2nd Edition .Pearson Education, 1999.
- V.Ganesan., "Gas Turbines", Tata McGraw-Hill Education, 3rd Edition, 2010.
- Philip Hill and Carl Peterson, "Mechanics and thermodynamics of propulsion", Pearson India, 2nd Edition, 2010.
- Cohen.H, Rogers.G.F.C. andSaravanamuttoo.H.I.H, "Gas turbine theory". Pearson education, 5th Edition, 2001.
- Saeed Farokhi, "Aircraft Propulsion", John Wiley & Sons, Inc ., 2009.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks**
 **Employability**

SAEA1503	COMPUTATIONAL FLUID DYNAMICS FOR AEROSPACE APPLICATION	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the concepts of fluid dynamics computationally.
- To evaluate the characteristics of flows.
- To know the basic methods of various computational methods.
- To discuss the structural grid generation and turbulence models.

UNIT 1 INTRODUCTION**9 Hrs.**

Historical Background-of Computations - Classification of Partial Differential Equations- Introduction to Navier-Stokes System of Equations. Comparison of numerical, analytical and experimental.

UNIT 2 FINITE DIFFERENCE METHODS AND SOLUTIONS**9 Hrs.**

Finite Difference Methods-Finite Element Methods - Finite Volume Methods, Neumann Boundary Conditions, Dirichlet Boundary Conditions Burgers' Equation- Coordinate Transformation for Arbitrary Geometries.

UNIT 3 INCOMPRESSIBLE VISCOUS FLOWS AND COMPRESSIBLE FLOWS**9 Hrs.**

Pressure Correction Methods -Semi-Implicit Method for Pressure-Linked Equations -Pressure Implicit with Splitting of Operators -Marker-and-Cell (MAC) Method.

UNIT 4 STRUCTURED AND UNSTRUCTURED GRID GENERATION**9 Hrs.**

Grid Generation: Introduction, Types of grid, Factors affecting the grid, Grid transformation, Prandtl-Mayer expansion waves, Stretched grids. : Numerical grid generation; basic ideas; transformation and mapping.

UNIT 5 COMPUTING TECHNIQUES AND APPLICATION**9 Hrs.**

Domain Decomposition Methods- Multigrid Methods- Parallel Processing- Turbulence Models- Zero-Equation Models- One-Equation Models -Two-Equation Models -Second Order Closure Models (Reynolds Stress Models) - Algebraic Reynolds Stress Models -Compressibility Effects- Direct Numerical Simulation- RANS- LES.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Recall history and evolution of computational fluid dynamics.
- CO2 - Compare the mathematical modeling and numerical methods.
- CO3 - Understand the working methodology of various computational fluid methods.
- CO4 - Recognize the various functions of major turbulence models.
- CO5 - Analyze the quality of structural grids and suitable shapes and methods for it.
- CO6 - Distinguish the problems application based.

TEXT / REFERENCE BOOKS

1. Chung T.J Computational fluid dynamics, second edition –Cambridge University press USA, 2010.
2. Suhas V Patankar, "Numerical Heat Transfer and Fluid Flow", Taylor and Francis, 2011.
3. Principles of Computational Fluid Dynamics by P. Wesseling., 2011.
4. Shaw C T, "Using Computational Fluid Dynamics" Prentice Hall, 1992.
5. Anderson.J.D.Jr. "Computational Fluid Dynamics: An Introduction", 3rd Edition, 2012.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****PART A:** 10 Questions of 2 marks each – No Choice**PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**Exam Duration: 3 Hrs.****20 Marks****80 Marks**
 **Employability**

SAEA1504	FINITE ELEMENT METHODS FOR AIRCRAFT STRUCTURES	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the concepts of finite elements methods.
- To evaluate the characteristics of structural members.
- To know the basic methods to solve the solid mechanics problems.
- To discuss the structural mechanics and its applications.

UNIT 1 INTRODUCTION**9 Hrs.**

Basic finite element concepts-Basic ideas in a finite element solution, General finite element solution procedure, Finite element equations using modified Galerkin method, Application: Axial deformation of bars, Axial spring element.

UNIT 2 BEAM BENDING**9 Hrs.**

Governing differential equation for beam bending, two node beam element, Exact solution for uniform beams subjected to distributed loads using superposition, Calculation of stresses in beams, Thermal stresses in beams

UNIT 3 ANALYSIS OF TRUSSES AND FRAMES**9 Hrs.**

Two dimensional truss element, three dimensional space truss element, Stresses due to lack of fit and temperature changes. Plane frame element, Thermal stresses in frames, Three dimensional space frame element

UNIT 4 TWO DIMENSIONAL ELASTICITY AND AXISYMMETRIC ELASTICITY**9 Hrs.**

Governing differential equations, Constant strain triangular element, Four node quadrilateral element, Eight node isoperimetric element. Problems-Governing equations for axisymmetric elasticity, Axisymmetric linear triangular element, Axisymmetric four nodes isoperimetric element

UNIT 5 APPLICATION FINITE ELEMENT METHODS**9 Hrs.**

Applications of FEM software to solve simple problems, types of solver, Applications based on general two dimensional boundary value Problem-Ideal fluid flows around an irregular object, Two dimensional steady state heat flow, Torsion of prismatic bars

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

CO1 - Recall history and evolution of finite element methods and analysis.

CO2 - Compare the mathematical modeling and numerical methods.

CO3 - Understand the working methodology of various finite element methods.

CO4 - Recognize the various functions of approximation methods.

CO5 - Analyze the quality of structural grids and suitable shapes and methods for it.

CO6 - Distinguish the problems application based.

TEXT / REFERENCE BOOKS

1. J.N Reddy. "An Introduction to the Finite Element Method" ,McGraw Hill, International Edition, 2011.
2. Seshu, P, "Text Book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi,2012.
3. Segerlind L.J, "Applied Finite Element Analysis", John Wiley, 2012.
4. Rao. S.S, "Finite Element Method in Engineering", Pergamon Press, 2013.
5. Chandrupatla & Belagundu , "Finite Elements in Engineering", Prentice Hall of India Private Ltd., 1997.
6. Cook, Robert Davis et al, "Concepts and Applications of Finite Element Analysis" , Wiley, John & Sons,1999.
6. George R Buchanan, "Schaum's Outline of Finite Element Analysis", McGraw Hill Company, 1994.
7. Taylor.C and Hughes.J.B. "Finite Element Programming of the Navier Stoke equation" Pineridge Press Limited, UK 1981.

END SEMESTER EXAMINATION QUESTION PAPERPATTERN**Max. Marks: 100****Exam Duration: 3Hrs****PART A:** 10 Questions of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks**
 **Employability**

SAEA1505	HIGH SPEED AERODYNAMICS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To introduce the concepts of compressibility.
- To make the student understand the theory behind the formation of shocks and expansion fans in Supersonic flows.
- To introduce the methodology of measurements in Supersonic flows.

UNIT 1 CONCEPTS OF COMPRESSIBLE FLOW**9 Hrs.**

Basic concepts of compressible flow, Review of continuity, energy and momentum equations. One dimensional inviscid flow; Stagnation quantities; Isentropic conditions. Speed of sound and Mach number; Isentropic relations; Area-velocity relation. Flow through constant area duct.

UNIT 2 COMPRESSION AND EXPANSION WAVES**9 Hrs.**

Normal shock –Prandtl equation and Rankine–Hugoniot relation. Oblique shock and supersonic compression by turning. Weak shocks and Mach waves; Supersonic expansion by turning. Prandtl-Meyer expansion fan; Reflection and intersection of shocks. Shock detachment and bow shock; Shock Expansion theory with application to thin airfoils.

UNIT 3 FLOW THROUGH DUCTS**9 Hrs.**

Flow through converging and diverging ducts. Flow through constant area duct with friction (Fanno flow)-Fanno flow equations and solutions-variation of flow properties- variation of Mach number with duct length. Flow through constant area duct with heat addition (Rayleigh flow)- Rayleigh line, Rayleigh flow equations-variation of flow properties.

UNIT 4 AIRFOIL IN HIGH SPEED FLOWS**9 Hrs.**

Lower and upper critical mach numbers, Lift and drag divergence, shock induced separation, characteristics of swept wings, Effects of thickness, camber and aspect ratio of wings, Transonic area rule, Tip effects. Lift, drag, Pitching moment and Centre of pressure for supersonic profiles, Shock-expansion theory, wave drag, supersonic wings, Design considerations for supersonic aircraft.

UNIT 5 EXPERIMENTAL TECHNIQUES FOR HIGH SPEED FLOWS**9 Hrs.**

Blow down, indraft and induction tunnel layouts and their design features. Transonic, supersonic and hypersonic tunnels and their peculiarities. Helium and gun tunnels, Shock tubes, Optical methods of flow visualization.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Apply the basic knowledge in mathematics, science and engineering.
- CO2 - Analyze how the aerodynamics affects the aircraft design and operation.
- CO3 - Analyze the concept of oblique shock waves and expansion waves.
- CO4 - Evaluate the one dimensional inviscid compressible flows.
- CO5 - Analyze the effect of presence of airfoil, wing and cone section in supersonic flows.
- CO6 - Analyze flow in transonic regime.

TEXT / REFERENCE BOOKS

1. Radhakrishnan, Ethirajan., Gas Dynamics, John Wiley & Sons,2010.
2. Anderson J. D., Jr., Modern Compressible Flow with Historical Perspective, McGraw Hill Publishing Co.,2004.
3. H W Liepmann and A Roshko, Elements of Gas Dynamics, John Wiley & Sons.
4. Shapiro, A.H., "Dynamics and Thermodynamics of Compressible Fluid Flow", Ronald Press.
5. Zucrow, M.J. and Anderson, J.D., "Elements of gas dynamics", McGraw-Hill Book Co., New York.
6. Clancy,L.J., "Aerodynamics", Pitman, Shroff Publishing co.,2006.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3Hrs****PART A:** 10 Questions of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks**
 **Employability**

SAEA3017	MANNED SPACE MISSIONS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- Know the advanced concepts of manned space missions to the engineers.
- Understand the space and environment and its conditions.
- Apply the concept of life supporting devices.

UNIT 1 FUNDAMENTALS OF SPACE MISSIONS**9 Hrs.**

The physics of space, Current missions: space station, Moon mission and Mars missions, Engineering challenges on Manned vs. unmanned missions, Scientific and technological gains from space programs, Salient features of Apollo and Space station missions, space shuttle mission.

UNIT 2 SPACE VS EARTH ENVIRONMENT**9 Hrs.**

Atmosphere: Structure and Composition, Atmosphere: Air Pressure, Temperature, and Density, Atmosphere: Meteoroid, Orbital Debris & Radiation Protection, Human Factors of Crewed Spaceflight, Safety of Crewed Spaceflight, Magnetosphere, Radiation Environment: Galactic Cosmic Radiation (GCR), Solar Particle Events (SPE), Radiation and the Human Body, Impact of microgravity and g forces on humans, space adaptation syndrome.

UNIT 3 LIFE SUPPORT SYSTEMS AND COUNTERMEASURES**9 Hrs.**

Life Support Systems and Space Survival Overview, Environment Controlled Life Support Systems (ECLSS), Human / Machine Interaction, Human Factors in Control Design, Crew Accommodations.

UNIT 4 MISSION LOGISTICS AND PLANNING**9 Hrs.**

Group Dynamics: Ground Communication and Support, Space Resources and Mission Planning - Space Mission Design: Rockets and Launch Vehicles - Orbital Selection and Astrodynamics, Entry, Descent, Landing, and Ascent, Designing and Sizing Space elements, Transfer, Entry, Landing, and Ascent Vehicles, Designing, Sizing, and Integrating a Surface Base, Planetary Surface Vehicles.

UNIT 5 SUBSYSTEMS**9 Hrs.**

Spacecraft Subsystems: Space Operations, Space Architecture, Attitude Determination and Control- Designing Power Systems, Extravehicular Activity (EVA) Systems, Space Robotics, Mission Operations for Crewed Spaceflight - Command, Control, and Communications Architecture.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Understand the working principles of basic control system.
- CO2 - Comprehend the sound foundation in the various subsystems.
- CO3 - Learn the advanced concepts of manned space missions to the engineers.
- CO4 - Understand the space and environment and its conditions.
- CO5 - Understand the the principle and performance of various subsystems.
- CO6 - Applying the importance of the mission logistics and planning.

TEXT / REFERENCE BOOKS

- Larson, W. J. and Pranke, L. K., Human Spaceflight: Mission Analysis and Design, McGraw-Hill Higher Education, Washington, DC, 1999
- McNamara, Bernard. 2010.
- Into the Final Frontier: The Human Exploration of Space (Brooks/Cole Publishing), 2012.
- Larson, W. J. and Pranke, L. K., Human Spaceflight: Mission Analysis and Design, McGraw-Hill Higher Education, Washington, DC, 1999
- McNamara, Bernard. 2013.
- Into the Final Frontier: The Human Exploration of Space, 2012.
- Connors, M.M., Harrison, A.A., and Akins, F.R. 2005. Living Aloft: Human Requirements for Extended Spaceflight, University Press of the Pacific, Honolulu, Hawaii: ISBN: 1-4102-1983-6
- Eckart, P. 1996. Spaceflight Life Support and Biospherics.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2 marks each – No Choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks.****Employability**

SAEA1601	AIRCRAFT STABILITY AND CONTROL	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To stability of aircraft at various flight conditions.
- To stability, control, and dynamic characteristics of aircraft.
- To evaluate the flight and handling qualities.
- To know the advances in flight dynamics and controls.

UNIT 1 BASIC CONCEPTS**9 Hrs.**

Aircraft Axis System, Coordinate Transformation, Aircraft Force and moment Equations, Basic Concept of Stability and Control, Types of stability.

UNIT 2 LONGITUDINAL DYNAMIC STABILITY AND CONTROL**9 Hrs.**

Longitudinal stability, Contribution of wing and Tail, Total contribution, Stick fixed and stick free stability, control effectiveness, hinge moment, tabs. Determination Of Neutral Points And Maneuver Points In Flight Tests. Aerodynamic balancing.

UNIT 3 MANEUVERABILITY**9 Hrs.**

Effects of freeing the stick. Control forces and force gradients. Critical conditions for stability and control. Effect of manoeuvres. Longitudinal dynamic stability, stability derivatives, characteristic equation for stick fixed case, modes and stability criterion, effect of freeing the stick.

UNIT 4 DYNAMIC STABILITY**9 Hrs.**

Brief description of lateral and directional dynamic stability- spiral, divergence and Dutch roll. Response, automatic control, autorotation and spin.

UNIT 5 MODERN CONTROL THEORY**9 Hrs.**

Classical vs modern control theory, introduction – state-space modelling, canonical transformation, controllability and observability, state-feedback design, application of modern control theory to aircraft autopilot design- stability augmentation, autopilot design, state observer, optimal control, problems. Introduction to aircraft autopilot design using classic control theory.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Study the applications of the conservation laws to flow.
- CO2 - Understand the importance of stability and control.
- CO3 - Understand the stability equations.
- CO4 - Understand the properties control system.
- CO5 - Analyze the modern control systems.
- CO6 - Distinguish the basics of autopilot systems.

TEXT / REFERENCE BOOKS

1. Thomas R. Yechout, 'An introduction to Aircraft Flight Mechanics', AIAA educational Series, 2003.
2. Bernard Etkin, Lloyd Duff Reid, Dynamics of Flight, Stability & Control, 3rd Edition, John Wiley & Sons, 1995.
3. Malcom J. Abzug, E.E. Larrabee, Airplane Stability & Control, 2nd Edition, Cambridge University Press, 2002.
4. Nelson. R.C., Flight Stability and Automatic Control, McGraw Hill, 1989.
5. Perkins C.D. and Hage R.E., Airplane Performance, Stability and Control, Wiley Toppan, 1974.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks**
 **Employability**

SAEA1602	THEORY OF VIBRATIONS AND AEROELASTICITY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the concepts of vibration and aero elasticity.
- To evaluate the characteristics of structural members.
- To know the basic methods to solve the solid mechanics problems.
- To discuss the structural mechanics and its applications.

UNIT 1 BASIC NOTIONS**9 Hrs.**

Simple harmonic motion – Terminologies – Newton's Law – D' Alembert's principle – Energy Methods.

UNIT 2 SINGLE DEGREE OF FREEDOM SYSTEMS**9 Hrs.**

Free vibrations – Damped vibrations – Forced Vibrations, with and without damping – support excitation – Vibration measuring instruments. Undamped vibration absorbers, Vibration isolation. Lagrangian's and Hamilton Equations.

UNIT 3 MULTI DEGREES OF FREEDOM SYSTEMS**9 Hrs.**

Two degrees of freedom systems – Static and Dynamic couplings vibration absorber Principal co- ordinates, Principal modes and orthogonal condition – Eigen value problems. Hamilton's principle- Lagrangean equation and application – Vibration of elastic bodies Vibration of strings- Longitudinal, Lateral and Torsional vibrations.

UNIT 4 APPROXIMATE METHODS**9 Hrs.**

Rayleigh's and Holzer Methods to find natural frequencies. Timoshenko beam, vibration of plates, collocation method, Myklested - prohl method.

UNIT 5 ELEMENTS OF AEROELASTICITY**9 Hrs.**

Concepts – Coupling – Aero elastic instabilities and their prevention – Basic ideas on wing. divergence, loss and reversal of aileron control – Flutter and its prevention.

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Recall history and evolution of vibration and aero elasticity.
- CO2 - Compare the mathematical modeling and numerical methods.
- CO3 - Understand the working methodology of various mechanical systems.
- CO4 - Recognize the various functions of approximation methods.
- CO5 - Analyze the quality of structural grids and suitable shapes and methods for it
- CO6 - Distinguish the problems application based.

TEXT / REFERENCE BOOKS

1. Bisplinghoff R.L., Ashley H and Hoffman R.L., "Aeroelasticity" – Addison Wesley Publication, New York, 2010.
2. Tse. F.S., Morse, I.F., Hinkle, R.T., "Mechanical Vibrations", – Prentice Hall, New York, 2011.
3. Scanlan R.H. & Rosenbaum R., "Introduction to the study of Aircraft Vibration and Flutter", John Wiley and Sons. New York, 1982.
4. Tongue. B. H., "Principles of Vibration", Oxford University Press, 2000.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs****PART A:** 10 Questions of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks**
 **Employability**

SAEA3016	FLIGHT VEHICLES' GUIDANCE AND CONTROL	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the concepts of guidance and control of flight vehicles.
- To evaluate the performance of flight vehicle's transformation.
- To know the basic functions of navigation.
- To discuss the methodology of modeling of aerospace vehicles.

UNIT 1 GUIDANCE**9 Hrs.**

Over view of flight vehicles: The initial conceptual sketches, L / D estimation. Initial takeoff weight build-up, empty weight estimation, historical trends, fuel fraction estimation, mission profiles, mission segment weight fractions, Review of governing equations of motion for aerospace vehicles, Linear systems analysis of aerospace systems, Applications - aircraft, spacecraft, missiles, launch vehicles.

UNIT 2 FLIGHT VEHICLE'S TRANSFORMATION**9 Hrs.**

Introduction to the concepts of navigation guidance and control: General principles of early conventional navigation systems. Geometric concepts of navigation. Reference frames. Direction cosine matrix, Euler angles, Transformation of angular velocities, Quaternion representation in co-ordinate transformation. Comparison of transformation methods.

UNIT 3 NAVIGATION**9 Hrs.**

Navigation: Navigation computation and error modeling, Inertial navigation systems, External navigation aids - GPS, Doppler radar, Star trackers, Multi-sensor fusion.

UNIT 4 PERFORMANCE**9 Hrs.**

Guidance: Guidance mission and performance, Guidance algorithm - guidance laws, single-dual-multi-mode guidance, Advanced guidance system design.

UNIT 5 MODELLING**9 Hrs.**

Modeling of Aerospace vehicles: Linear system analysis, Stabilization and Control of space crafts, Missile control systems and Autopilots, Launch vehicle flight control systems. Longitudinal and lateral autopilots for aircraft. Radar systems command and housing guidance system.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Recall basics of flight mechanics.
- CO2 - Understand the basic working principle of guidance and control of flight vehicles.
- CO3 - Understand the working of flight transformation in various planes.
- CO4 - Recognize the functions guidance algorithm.
- CO5 - Understand the missile control system.
- CO6 - Distinguish the basics of functions of radar and launch vehicle flight control system.

TEXT / REFERENCE BOOKS

1. Flight without Formulae by A.C Kermode, Pearson Education, 10th Edition, 2011.
2. Mechanics of Flight by A.C Kermode, Pearson Education, 5th Edition, 2012.
3. Fundamentals of Flight, Shevell, Pearson Education, 2nd Edition, 2013.
4. 'Modern Navigation, Guidance and Control Processing, Ching-Fang Lin, Prentice Hall Inc., Englewood Cliffs, New Jersey, 2011.
5. 'Guided Weapon Control Systems', Garnele P, Pergamon, 1980.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2 marks each – No Choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks**

Entrepreneurship

PRACTICAL SAEA2603	AIRCRAFT DESIGN PROJECT LAB	L	T	P	Credits	Total Marks
		0	0	4	2	100

COURSE OBJECTIVES

- To classify the types of Aircrafts and its data collection.
- To estimate the weight of an Aircraft pertaining to preliminary hand calculations
- To select the appropriate airfoil, wing tail, control surface and power plant for the preliminary design Aircraft.
- To analyze the performance of the preliminary design Aircraft.
- To perform the structural analysis of the preliminary design Aircraft.
- To design the landing gear opted for the newly designed Aircraft.

SUGGESTED LIST OF EXPERIMENTS

1. Data collection.
2. Preliminary weight estimation.
3. Airfoil selection, Wing tail and control surfaces
4. Power plant selection
5. Balance diagram.
6. Drag estimation.
7. Rate of climb calculations at various altitudes, Turn performance
8. Range and Endurance, Takeoff and landing distance calculation
9. Stability calculations
10. V-n diagram
11. Wing and fuselage Design.
12. Shear force and bending moment diagrams of various aircraft structures.
13. Structural weight distribution.
14. Landing gear Design.
15. Detailed CAD drawings of wing, fuselage ,tail surfaces and control surfaces and their stress analysis using structural software
16. Detailed Design project report.

COURSE OUTCOMES

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

- CO1: Categorize the types of Aircraft and its specifications to perform the conceptual design of new Aircraft.
- CO2: Estimate the gross weight and payload weight of an Aircraft for the preliminary designed Aircraft.
- CO3: Deduct the appropriate selection of airfoil, wing-tail configuration for the preliminary Aircraft.
- CO4: Analyze the preliminary designed Aircraft's performance and its control.
- CO5: Evaluate the structural analysis of airframe parts of the preliminary designed Aircraft.
- CO6: Design the appropriate landing gear that suits the preliminary designed Aircraft.

SAEA1702	UNMANNED AERIAL VEHICLE DESIGN	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To introduce the concepts of applying aerodynamics to UAV Design.
- To familiarize the student's ability to analyse the concepts of Avionics.
- To understand the basics of navigation in UAV Design.
- To understand the basics of Image Processing.

UNIT 1 INTRODUCTION TO UAV**9 Hrs.**

History of UAV –classification –basic terminology- The Systemic Basis of UAV-System Composition- Conceptual Phase- Preliminary Design-Selection of the System- Some Applications of UAV- Characteristics Of Aircraft Types.

UNIT 2 BASICS OF AERODYNAMICS AND AIRFRAME CHARACTERISTICS OF UAV**9 Hrs.**

Lift-induced Drag - Parasitic Drag - Rotary-wing Aerodynamics - Response to Air Turbulence- Airframe –dynamics – modelling- structures –wing design- engines types-equipment maintenance and management-control surfaces-specifications.

UNIT 3 AVIONICS HARDWARE**9 Hrs.**

Geysering Phenomenon. Autopilot –AGL-pressure sensors-servos-accelerometer –gyros-actuators- power supply processor, integration, installation, configuration, and testing.

UNIT 4 COMMUNICATION PAYLOADS, CONTROLS AND NAVIGATION**9 Hrs.**

Payloads-Telemetry-tracking-Aerial photography-controls-PID feedback-radio control frequency , range –SAS-flight director- commands and videos-elements of control loops-flight computer, -Sensors- Waypoints navigation.

UNIT 5 DIGITAL IMAGE PROCESSING FOR UAV**9 Hrs.**

Principles of digital aerial photography- Sensors for aerial photography - Photo-interpretation, objective analysis and image quality - Image Recognition - Image Classification – Image Fusion – Colour Image Processing - Video Motion Analysis.

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Understand the working principles of Unmanned Aerial Vehicle.
- CO2 - Comprehend the sound foundation in the Aerodynamics and Airframe characteristics.
- CO3 - Learn the operation of Avionics Hardware.
- CO4 - Understand the concept of Communication payloads.
- CO5 - Understand the principle and performance of control and navigation.
- CO6 - Applying the importance of Digital image processing for UAV.

TEXT / REFERENCE BOOKS

1. Kimon P. Valavanis, George J. Vachtsevanos, " Handbook of Unmanned Aerial Vehicles " Volume Set- FIRST Edition, ISBN-13: 978-9048197064, 2015.
2. R. Jha. "Theory, Design, and Applications of Unmanned Aerial Vehicles".1st Edition, 2015.
3. Jane's Unmanned Aerial Vehicles and Targets, Jane' s Information Group; ASIN: 071 061 2575,1999.
4. Alex Elliott,"Build Your Own Drone Manual: The practical guide to safely building, operating and maintaining an Unmanned Aerial Vehicle (UAV)".2016.
5. R. Said and H. Chayeb, "Power supply system for UAV", KTH, 2002.
6. Robert C. Nelson, Flight Stability and Automatic Control, McGraw -Hill, Inc, 1998.
7. Skafidas, "Microcontroller Systems for a UAV", KTH, TRITA-FYS 2002:51 ISSN 0280-316 X.34, 2002.
8. Kimon P. Valavanis, "Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy", Springer, 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****Part A:** 10 Question of 2 marks each – No choice**20 Marks****Part B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks**

SAEA4002	Fundamentals of Aerospace Technology	L	T	P	C
		3	0	0	3

UNIT1 BASIC PROPERTIES OF ATMOSPHERE

9Hrs.

Heat, Temperature, and Temperature Scales - The Electromagnetic Spectrum - Composition of the Atmosphere - Layers in the atmosphere are defined by temperature profiles, How pressure varies in the atmosphere - Principal weather instruments – Earth's Radiation Belts.

UNIT2 CLASSIFICATION OF AEROSPACE VEHICLES

9Hrs.

Fixed wing Aircraft – Classification of Aircraft, Aircraft as a Space Launcher assistance – Rotorcraft – Classification of Rotorcraft – Missiles – Classification of Missiles, Missile technology missions – Space Vehicles – classification of space vehicles.

UNIT3 SATELLITE MISSION AND CONFIGURATION

9Hrs.

Mission Overview – Requirements for different missions – Spacecraft configuration - Spacecraft Bus–Payload–Requirements and constraints– Initial configuration decisions and Trade-offs–Spacecraft configuration process– Broad design of Spacecraft Bus–Subsystem layout–Types of Satellites–Constellations– Applications

UNIT4 FUNDAMENTALS OF MISSILE SYSTEMS

9Hrs.

History of guided missile for defence applications- Classification of missiles– The Generalized Missile Equations of Motion- Coordinate Systems- Lagrange's Equations for Rotating Coordinate Systems-Rigid-Body Equations of Motion-missile system elements, missile ground systems.

UNIT5 SPACE ENVIRONMENT

9Hrs.

Peculiarities of space environment and its description– effect of the space environment on materials of spacecraft structure and astronauts- manned space missions – effect on satellite life time

Max.45Hrs.

COURSE OUTCOMES:

CO1: Describe the layers in the atmosphere and earth's radiation belts.

CO2: Classify the space launchers, missiles, rotorcraft and aircrafts for different applications.

CO3: Categorize the satellite mission configuration and types of satellites required for different applications.

CO4: Estimate the missile equations of motion in static and rotating coordinate system

CO5: Analyse the rigid body equation of motion for missile systems.

CO6: Synthesize the effect of the space environment on materials of spacecraft structures and astronauts.

TEXT/REFERENCEBOOKS

1. Cornelisse, J.W., "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd, London, 1982
2. Siouris, G.M. "Missile Guidance and control systems", Springer, 2003.
3. James R. Wertz and Wiley J. Larson, "Space Mission Analysis and Design", (Third Edition), 1999.
4. Charles D. Brown, "Spacecraft Mission Design", AIAA Education Series, Published by AIAA, 1998
5. Van de Kamp, "Elements of astromechanics", Pitman Publishing Co., Ltd., London, 1980.



Skill development

SAEA1201	AIRCRAFT MATERIALS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To introduce the concepts of applying the Materials to Aircraft.
- To make the student understanding the concept of Mechanical Behaviors of Materials.
- To understand the basics of Corrosion & heat treatment.
- To understand the basics of Ceramics and High temperature materials.

UNIT 1 ELEMENTS OF AEROMATERIALS**9 Hrs.**

Structure of solid materials – Atomic structure of materials – crystal structure – miller indices – density – packing factor – space lattices – x-ray diffraction – imperfection in crystals – physical metallurgy – general requirements of materials for aerospace applications.

UNIT 2 MECHANICAL BEHAVIOUR OF MATERIALS**9 Hrs.**

Linear and nonlinear elastic properties – Yielding, strain hardening, fracture, Baughinger's effect – Notch effect testing and flaw detection of materials and components – creep and fatigue – comparative study of metals, ceramics plastics and composites.

UNIT 3 CORROSION & HEAT TREATMENT OF METALS AND ALLOYS**9 Hrs.**

Types of corrosion – effect of corrosion on mechanical properties – stress corrosion cracking – corrosion resistance materials used for space vehicles heat treatment of carbon steels – aluminium alloys, magnesium alloys and titanium alloys – effect of alloying treatment, heat resistance alloys – tool and die steels, magnetic alloys.

UNIT 4 CERAMICS AND COMPOSITES**9 Hrs.**

Introduction – powder metallurgy – modern ceramic materials – cutting tools – glass ceramic – production of semi-fabricated forms – plastics and rubber – carbon/carbon composites, fabrication processes involved in metal matrix composites – shape memory alloys – applications in aerospace vehicle design, open and close mould processes.

UNIT 5 HIGH TEMPERATURE MATERIALS CHARACTERIZATION**9 Hrs.**

Classification, production and characteristics – methods and testing – determination of mechanical and thermal properties of materials at elevated temperatures – application of these materials in thermal protection systems of aerospace vehicles – super alloys.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Understand the role of corrosion in Aircraft.
- CO2 - Comprehend the sound foundation in the design principles of heat treatment processes.
- CO3 - Knowledge in usage of composite materials in aircraft component design.
- CO4 - Exposure to high temperature materials for space applications.
- CO5 - Understand the principle and performance of Ceramics.
- CO6 - Applying the importance of Materials in Aerospace.

TEXT / REFERENCE BOOKS

1. Titterton.G., "Aircraft Materials and Processes", V Edition, Pitman Publishing Co., 2010.
2. Martin, J.W., "Engineering Materials, Their properties and Applications", Wykedham Publications (London) Ltd., 2011.
3. Van Vlack.L.H., "Materials Science for Engineers", Addison Wesley, 2011.
4. Raghavan.V., "Materials Science and Engineering", Prentice Hall of India, New Delhi, 2012.
5. S.O.Kasap, Principles of Electronic Materials and Devices, Tata McGraw Hill Edition, New Delhi, 2013.
6. C. G. Krishnadas Nair "Handbook of Aircraft Materials" Interline, 1993.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks****Skill development**

SAEA1303	AIRCRAFT SYSTEMS AND INSTRUMENTS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To impart knowledge of the hydraulic and pneumatic systems components.
- To understand the types of instruments and its operation including navigational instruments to the students.

UNIT 1 AIRCRAFT SYSTEMS**9 Hrs.**

Hydraulic Systems – Types of Hydraulic oil -and its properties. Study of Typical Workable System – Components– Hydraulic System Components – Modes of Operation – Pneumatic Systems – Advantages – Working Principles –Components, case studies in modern aircrafts

UNIT 2 LANDING GEAR SYSTEMS**9 Hrs.**

Landing Gear Systems – Classification – Purpose and types of Shock Absorbers. construction and its operation– LG - Retraction/extension Mechanism. Brake System types, components and advantages, antiskid system. Conventional and tubeless tires construction, advantages and common defects, modern advancements in tyre technologies. Brake systems.

UNIT 3 FUEL AND PRESSURIZING SYSTEM**9 Hrs.**

Fuel system – Layout, Types of fuel tanks, locations, control pressure, sequence of fuel consumption, Basic Air Cycle Systems – Vapour Cycle Systems. Pressurization system – Principle-components-limitation- Oxygen systems – Fire Protection Systems, Deicing and Anti Icing Systems.

UNIT 4 AIRPLANE CONTROL SYSTEMS**9 Hrs.**

Conventional Systems –Modern Flight Control Systems Control Actuation Digital Fly by Wire systems – Autopilot System. Active Control Technology – CCV, The Control Problem, Principles of actuation systems, Types of actuation systems.

UNIT 5 AIRCRAFT INSTRUMENTS**9 Hrs.**

Flight Instrument and Navigation Instruments – Accelerometers, Air data instruments-airspeed, altitude, Vertical speed indicators. Static Air temperature, Angle of attack, Air Speed Indicators – Mach Meters – Altimeters – Gyroscopic Instruments – principles and Operation and types– Study of Various Types of Engine Instruments – Tachometers – Temperature Gauges – Pressure Gauges – Operation and Principles.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Describe the basic concepts of various hydraulic and pneumatic systems components in aircraft.
- CO2 - Recognize various types of Aircraft instruments.
- CO3 - Understanding the basics of various fuel and pressurizing system.
- CO4 - Understanding the working principle of Modern Flight Control Systems.
- CO5 - Understanding gyroscopic instruments in aircraft production.
- CO6 - Understanding the Flight Instrument and Navigation Instruments used in aircraft Production.

TEXT / REFERENCE BOOKS

1. Mekinly, J.L. and Bent, R.D., "Aircraft Power Plants", McGraw Hill, 1993.
2. Pallet, E.H.J., "Aircraft Instruments & Principles", Pitman & Co., 1993.
3. Treager, S., "Gas Turbine Technology", McGraw Hill, 1997.
4. Mckinley, K.L., and Bent, R.D., "Aircraft Maintenance & Repair", McGraw Hill 1993
5. General Hand Books of Airframe and Power plant Mechanics", U.S. Dept. of Transportation, Federal Aviation Administration, .the English Book Store, New Delhi, 1995.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks****Skill development**

SAEA 1304	INTRODUCTION TO AERODYNAMICS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the concepts of fluids and its properties.
- To evaluate the performance of fluids and fluid flows in International standard atmosphere.
- To know the basic functions of fluids and fluid flows and measuring instruments.
- To discuss fluid properties in the basis of the structural, aerodynamics.

UNIT 1 FLUID PROPERTIES & EQUATIONS OF MOTION**9 Hrs.**

Properties of fluids—Specific gravity, specific weight, viscosity, compressibility, vapor pressure and gas laws – capillarity and surface tension. Flow characteristics: concepts of system and control volume. Application of control volume to continuity equation, energy equation, momentum equation and Bernoulli's principle and its applications— Orifice meter, venturimeter, pitot –tube.

UNIT 2 DIMENSIONAL ANALYSIS AND FLUID FLOW IN CLOSED CONDUITS**9 Hrs.**

Dimensional Analysis Buckingham Pi - theorem, Derivations and applications of important dimensionless numbers, basic modeling and similitude. Pipe friction, Darcy-Weisbach equation and chezy's formula, Pipe losses - Major and Minor losses - Problems of parallel, series and branched pipes.

UNIT 3 FLUID FLOW OVER BODIES AND BOUNDARY LAYER THEORY**9 Hrs.**

Boundary layer theory-boundary layer development on a flat plate, displacement thickness, momentum thickness, Energy thickness, momentum integral equation, drag on flat plate.

UNIT 4 PUMPS AND TURBINES**9 Hrs.**

Impact of jets Centrifugal Pumps, Hydraulic Turbines: Classification of hydraulic turbines – Working principle of Pelton wheel, Francis and Kaplan turbines –velocity triangles- Propeller fundamentals.

UNIT 5 BASIC AERODYNAMICS**9 Hrs.**

Types of flow - velocity field and acceleration. Viscous fluid flow - Laminar and turbulent flow. Theory of streamline, Stream function, velocity potential, relation between stream function and velocity potential, circulation. Basic elementary flows— Source, sink, free and forced vortex, uniform parallel flow.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Study the applications of the conservation laws to flow through pipes and hydraulic machines.
- CO2 - Understand the importance of dimensional analysis.
- CO3 - Understand the importance of various types of flow in pumps and turbines.
- CO4 - Understand the properties of basic flows.
- CO5 - Analyze the fluid behaviors.
- CO6 - Distinguish the basics of fluid statics and fluid dynamics.

TEXT / REFERENCE BOOKS

1. Bansal.R.K., "Fluid Mechanics & Hydraulics Machines", 9th Edition, Laxmi Publications, 2010.
2. Kumar, K.L., Fluid Mechanics, 2nd Edition, Tata McGraw-Hill, New Delhi, 2012.
3. Irving H. Shames, Fluid Mechanics, 3rd Edition, McGraw-Hill, 2012.
4. Robert W. Fox and Alan T. McDonald, Introduction to Fluid Mechanics, 5th Edition, John Wiley and Sons, Inc., U.K.
5. Douglas. J. F., Gasiorek. J. M., Swaffield. J. A., "Fluid Mechanics ELBS", 4th Edition, Prentice Hall, 2000.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks****Skill development**

SAEA1305	INTRODUCTION TO AIRCRAFT STRUCTURES	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- At the end of this course, the student will have knowledge about the behavior of aircraft structural members.
- Subjected to various types of forces. The subject can be mastered best by solving numerous problems.

UNIT 1 CONCEPT OF SIMPLE STRESSES AND STRAINS**9 Hrs.**

Concept of stress and strain, Hooke's law-Tension, Compression, and Shear, stress-strain diagram-Poisson's ratio, elastic constants and their relationship- Deformation of simple and compound bars. Principal plane, principal stress, maximum shearing stress - Uniaxial, biaxial state of stress-Mohr's circle for plane stresses.

UNIT 2 ANALYSIS OF BEAMS**9 Hrs.**

Types of beams and loads-shear force and bending moment diagrams for cantilevers, simply supported and overhanging beams. Theory of pure bending- assumptions in the simple bending theory, Flexure formula: its application to beams of rectangular, circular and channel, I&T Sections, Combined direct and bending stresses in fore mentioned sections.

UNIT 3 DEFLECTION OF BEAMS**9 Hrs.**

Differential Equation of the Elastic Axis-Deflection and slope of beams-Double Integration, Area Moment and Macaulay's methods for simply supported, Cantilever and overhanging beams.

UNIT 4 STRESSES IN SHAFTS, HELICAL SPRINGS AND THIN PRESSURE VESSELS**9 Hrs.**

Torsion of Circular Shafts-Shear Stresses and Twist in Solid and Hollow Shafts. Close and open Coil Helical springs. Stresses in Thin Walled Pressure Vessels.

UNIT 5 COLUMNS AND FAILURE THEORIES**9 Hrs.**

Columns- Member subjected to combined bending and axial loads, Euler's theory, Crippling load, Rankine's theory. Failure theories - Maximum Stress theory – Maximum Strain Theory – Maximum Shear Stress Theory – Distortion Theory – Maximum Strain energy theory.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

- CO1 - Analysis of different types of stresses and strains.
- CO2 - Analysis of different types of beams and loads acting on it.
- CO3 - Analysis of deflections in beams.
- CO4 - Analysis of stresses in shafts, helical springs and pressure vessels.
- CO5 - Analysis of Column structure and understanding of failure theories.

TEXT / REFERENCE BOOKS

1. Malhotra, D.R. and Gupta, H.C., "The Strength of Materials", Satya Prakashan Tech. India Publications, New Delhi, 2011.
2. Kazimi, S.M.A., "Solid Mechanics", Tata McGraw Hill, 1976. Dym, C.L. and Shames I.H., "Solid Mechanics", McGraw Hill, Kogakusha, Tokyo, 2012.
3. Timoshenko, S., Young, "Elements of Strength of Material", Vol. I & II, T. Van Nostrand Co Inc, Princeton, N.J. 2012.
4. Ferdinand P. Beer, and Russell Johnston, E., "Mechanics of Materials", SI Metric Edition, McGraw Hill, 2011.
5. Rajput, R.K., "Strength of materials", Fourth Edition, S. Chand Limited, 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Question of 2 marks each – No choice**20 Marks****PART B:** 2 Questions from each unit of internal choice, each carrying 16 marks**80 Marks****Skill development**

SAEA2301	AIRCRAFT STRUCTURE LAB - I	L	T	P	Credits	Total Marks
		0	0	4	2	100

COURSE OBJECTIVE

- Experimental analysis of various structures used in aerospace industry.

SUGGESTED LIST OF EXPERIMENTS

1. Tensile testing using UTM, Mechanical and Electrical extensometers. Stress Strain curves and strength tests for Steel and Aluminum.
2. Comparison of hardness values of steel, copper and aluminum using Brinell and Rockwell hardness measuring machines.
3. Compression test on Aircraft Materials.
4. Estimation of spring constant under tension and compression.
5. Estimation of notch toughness of Steel using Charpy / Izod impact testing machine
6. Tensile tests on riveted and bolted joints.
7. Verification of Castigliano's theorems. Influence coefficients
8. Bending tests, Stress and deflection of beams with various end conditions.
9. Verification of Maxwell's theorem.
10. Compression tests on long columns. Critical buckling loads, Euler load by Southwell plot.

COURSE OUTCOMES

On completion of the course, student will be able to

- CO1 - Compare the hardness values of steel, copper and aluminium.
- CO2 - Perform tensile and compression tests on given specimens.
- CO3 - Estimation of toughness of the given specimen.
- CO4 - Verification of Maxwell's and Castigliano's theorem.
- CO5 - Understand about Critical buckling loads.
- CO6 - Understand about rivets.



Skill development

SAEA2401	AERODYNAMICS LAB	L	T	P	Credits	Total Marks
		0	0	4	2	100

COURSE OBJECTIVE

- To predict different aerodynamics used in aero application.

SUGGESTED LIST OF EXPERIMENTS

1. Calibration of subsonic wind tunnel.
2. Pressure distribution over cylinder.
3. Study of lift, drag characteristics of airfoils using wind tunnel.
4. Study of pitching moment characteristics of airfoil.
5. Measurement of boundary layer thickness.
6. Flow visualization technique by using water flow channel.
7. Computational flow analysis of bluff bodies.
8. Computational flow analysis of wing with different angle of attack.
9. Numerical analysis of shock tube.
10. C_D and C_L formulation using computational flow techniques.
11. Numerical analysis of von Karman vortex sheets.

COURSE OUTCOMES

On completion of the course, student will be able to

- CO1 - Measure the velocity of the subsonic wind tunnel at various RPM.
- CO2 - Coefficient of Lift and drag for symmetric and unsymmetrical aerofoils are analysed.
- CO3 - Identify the various flows acting on the aerofoil.
- CO4 - Study the Supersonic flow and characteristics of it.
- CO5 - Boundary layer concepts.
- CO6 - Simulation of aerodynamics experiments in CFD software.



Skill development

SAEA2402	AIRCRAFT STRUCTURE LAB - II	L	T	P	Credits	Total Marks
		0	0	4	2	100

COURSE OBJECTIVE

- Experimental and computational analysis of various structures used in aerospace industry.

SUGGESTED LIST OF EXPERIMENTS

1. Unsymmetrical Bending of a Cantilever Beam
2. Combined bending and Torsion of a Hollow Circular Tube
3. Material Fringe Constant of a Photo elastic Model
4. Shear Centre calculation of an open section.
5. Shear Centre calculation of a closed section.
6. Free Vibration of a Cantilever Beam
7. Wagner beam – Tension field beam
8. Computational Methods involving Aerospace Structures
9. Determination of Natural frequency and mode shape of metal plate with various end conditions
10. Determination of Natural frequency and mode shape of composite plate with various end conditions

COURSE OUTCOMES

On completion of the course, student will be able to

- CO1 - Perform computational methods involving Aerospace structures.
- CO2 - Determine natural frequency of the given plate.
- CO3 - Analyze photo elastic models.
- CO4 - Calculate shear center location of the given section.
- CO5 - Understand about Wagner beam.
- CO6 - Understand about Free Vibration of a Cantilever Beam.



Skill development

SAEA3014	BOUNDARY LAYER THEORY	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the importance of boundary layer in Aerodynamics.
- To understand various types of boundary layers and their applications.

UNIT 1 VISCOUS FLOW EQUATIONS**9 Hrs.**

Navier-Stokes Equations, Creeping motion, Couette flow, Poiseuille flow through ducts, Ekman drift.

UNIT 2 LAMINAR BOUNDARY LAYER**9 Hrs.**

Development of boundary layer – Estimation of boundary layer thickness, Displacement thickness - Momentum and energy thicknesses for two dimensional flow – Two dimensional boundary layer equations – Similarity solutions - Blasius solution.

UNIT 3 TURBULENT BOUNDARY LAYER**9 Hrs.**

Physical and mathematical description of turbulence, two-dimensional turbulent boundary layer equations, Velocity profiles – Inner, outer and overlap layers, Transition from laminar to turbulent boundary layers, turbulent boundary layer on a flat plate, mixing length hypothesis.

UNIT 4 APPROXIMATE SOLUTION TO BOUNDARY LAYER EQUATIONS**9 Hrs.**

Approximate integral methods, digital computer solutions – Von Karman – Polhausen method.

UNIT 5 THERMAL BOUNDARY LAYER**9 Hrs.**

Introduction to thermal boundary layer – Heat transfer in boundary layer - Convective heat transfer, importance of non dimensional numbers – Prandtl number, Nusselt number, Lewis number etc.

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, student will be able to

CO1 - Apply the basic fundamentals of Different types of Boundary layer thickness.

CO2 - Analyze the behavior of the fluid flow under static condition.

CO3 - Understand the basics of Different types of flow such as Laminar, turbulent and compressible flow, Incompressible flow, Viscid and Inviscid flow.

CO4 - Basics of Boundary layer Control.

CO5 - Flow through pipe of different types of flow.

CO6 - Importance of non-dimensional numbers.

TEXT / REFERENCE BOOKS

- Schlichting H., "Boundary Layer Theory", McGraw Hill, New York, 2010.
- Frank White, Viscous Fluid flow, McGraw Hill, 2011.
- Reynolds A.J., "Turbulent flows in Engineering", John Wiley & Sons, 2013.
- Ronald L., Panton, "Incompressible fluid flow", John Wiley & Sons, 1984.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2 marks each – No Choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks****Skill development**

SAEA3015	HIGH TEMPERATURE MATERIALS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To learn damage mechanism and failure of components of elevated temperatures.
- To know the basic functions of creep and fracture of materials.
- To discuss the oxidation and hot corrosion.

UNIT 1 CREEP**9 Hrs.**

Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate.

UNIT 2 DESIGN FOR CREEP RESISTANCE**9 Hrs.**

Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep, ductile and brittle materials, Monk man-Grant relationship.

UNIT 3 FRACTURE**9 Hrs.**

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture, ductile fracture due to micro void coalescence-diffusion controlled void growth; fracture maps for different alloys and oxides.

UNIT 4 OXIDATION AND HOT CORROSION**9 Hrs.**

Oxidation, Pilling, Bed worth ratio, kinetic laws of oxidation- defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion.

UNIT 5 SUPERALLOYS AND OTHER MATERIALS**9 Hrs.**

Iron base, Nickel base and Cobalt base super alloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening.

Max.45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Recall the basics of materials.
- CO2 - Understand the behavior of creep and fracture.
- CO3 - Understand the oxidation and hot corrosion.
- CO4 - Recognize the functions of super alloys.
- CO5 - Analyze the ductile and brittle materials.
- CO6 - Analyze the temperature strain rate.

TEXT /REFERENCE BOOKS

1. Raj. R., "Flow and Fracture at Elevated Temperatures", American Society for Metals USA, 2011.
2. Hertzberg R.W., "Deformation and Fracture Mechanics of Engineering materials", 4th Edition, John Wiley, USA, 2012.
3. Courtney T.H, "Mechanical Behaviour of Materials", McGraw Hill, USA, 2012.
4. Boyle J.T, Spencer J, "Stress Analysis for Creep", Butterworths, UK, 2013.
5. Bressers.J., "Creep and Fatigue in High Temperature Alloys", Applied Science, 1981.
6. McLean D., "Directionally Solidified Materials for High Temperature Service", The Metals Society, USA, 1985.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2 marks each – No Choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks****Skill development**

SAEA3019	ORBITAL MECHANICS	L	T	P	Credits	Total Marks
		3	0	0	3	100

COURSE OBJECTIVES

- To understand the concepts of satellite injection.
- To evaluate the satellite perturbations, trajectory computation.
- To know the basic functions of travel and flight of ballistic missiles.
- To discuss the stages of separation.

UNIT 1 BASIC CONCEPTS**9 Hrs.**

The solar system -Reference frames and coordinate systems –The celestial sphere -The ecliptic -Motion of vernal equinox – Sidereal time-Solar time-Standard time-The earth's atmosphere. Types of orbit.

UNIT 2 THE GENERAL N-BODY PROBLEM**9 Hrs.**

The Many body problem - Lagrange - Jacobi identity - The circular restricted three body problem – Libration points-Relative Motion in the N-body problem-The two-body problem-Satellite orbits - Relations between position and time-Orbital elements.

UNIT 3 SATELLITE INJECTION AND SATELLITE ORBIT PERTURBATIONS**9 Hrs.**

General aspects of satellite injections-Satellite orbit transfer-Various cases-Orbit deviations due to injection errors-Special and general perturbations-Cowell's Method - Encke's method – Method of variations of orbital elements General perturbations approach.

UNIT 4 INTERPLANETARY TRAJECTORIES BALLISTIC MISSILE -TRAJECTORIES**11 Hrs.**

Two-dimensional inter planetary trajectories –Fast interplanetary trajectories –Three dimensional interplanetary trajectories-Launch of interplanetary spacecraft –Trajectory about the target planet. The boost phase-The ballistic phase -Trajectory geometry -Optimal flights -Time of flight-Re-entry phase –The position of the impact point Influence coefficients.

UNIT 5 MATERIALS FOR SPACE CRAFT**7 Hrs.**

Space environment-Peculiarities -Effect of space environment on the selection of materials of spacecraft.

Max. 45 Hrs.**COURSE OUTCOMES**

On completion of the course, students will be able to

- CO1 - Study the basic concepts of orbits and its types.
- CO2 - Understand the satellite perturbations, trajectory computation.
- CO3 - Understand the importance of missile performance.
- CO4 - Understand the properties control system.
- CO5 - Analyze the trajectory calculations and materials.
- CO6 - Distinguish the basics of fluid statics and fluid dynamics for propulsion.

TEXT / REFERENCE BOOKS

- George .P.Sutton , Oscar Biblarz "Rocket Propulsion Elements", Wiley Publishers 8th Edition, 2010.
- J.ohn H. Blakelock, "Automatic control of aircraft and missiles", 2nd Edition, Wiley Publishers, 2011.
- George.M.Siouris "Missile guidance and control systems", Springer 2nd Edition, 2004.
- Tactical and Strategic Missile Guidance, 5th Edition, Paul Zarchan, Progress in Astronautics and Aeronautics, AIAA, 2007, ISBN-10: 1-56347-874-9.
- Missile Guidance and Control Systems, George M. Siouris, Springer-Verlag, 2004, ISBN: 0-387-00726.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN**Max. Marks: 100****Exam Duration: 3 Hrs.****PART A:** 10 Questions of 2 marks each – No Choice**20 Marks****PART B:** 2 Questions from each unit of internal choice; each carrying 16 marks**80 Marks****Skill development**