THE VISION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

The Department of Aerospace Engineering shall strive to be a globally known department, committed to its academic excellence, professionalism and societal expectations. The department aims to impart state of the art technical knowledge, practical skills, leadership qualities, team spirit, ethical values and entrepreneurial skills to make all the students capable of taking up any task relevant to the area of Aerospace Engineering.

THE MISSION OF THE DEPARTMENT OF AEROSPACE ENGINEERING

1. To prepare the students to have a sound/very good fundamental knowledge to meet the present and future needs of industries.
2. To improve the technical knowledge of the students in tune with the current requirements through collaboration with industries and research organization.
3. To make the students gain enough knowledge in various aspects of system integration.
4. To motivate the students to take up jobs in national laboratories and aerospace industries of our country.
5. To stimulate interest to pursue inter and multidisciplinary research, sponsored and consultancy projects with industries and research establishments.
6. To encourage the faculty members and students to do research and update themselves with the latest developments in the area of Aerospace Engineering.
7. To encourage students to initiate startup companies in Aerospace domain.

PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

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<td>1</td>
<td>Engineering knowledge</td>
<td>Postgraduate will be able to use the Engineering knowledge acquired from the basic courses offered in the programme to pursue either doctoral studies or a career as an academician, scientist or engineer.</td>
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2. **Conduct investigations of complex problems**

   Postgraduate will have a firm scientific, technological and communication base that helps him/her to conduct investigations of complex problems in the Aerospace industry and R&D organizations related to Aeronautical engineering and other professional fields.

3. **The Engineer and society**

   Postgraduate will be capable of doing research in inter and multidisciplinary areas which will result in more efficient and cheaper products that are beneficial to society.

4. **Environment and sustainability**

   Postgraduate will exhibit awareness of contemporary issues of environment focusing on the necessity to develop new materials, design and testing methods for the solution of environmental problems related to Aerospace industry.

5. **Individual and team work**

   Postgraduate will exhibit capability towards design and development of airframes from system integration point of view that requires team work.

6. **Report writing skill**

   Postgraduate will have the ability to write and present a Comprehensive technical report and research article.

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**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

**PEO 1: Successful Moulding of Graduate into Aerospace Technology Professional:**

Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of Aerospace technology through rigorous post graduate education.

**PEO 2: Successful Career Development:**

Graduates of the programme will require the ability to have successful technical and managerial career in Aerospace industries and the allied management organisations.

**PEO 3: Contribution to Aerospace Technology Field:**

Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aerospace industries.

**PEO 4: Sustainable interest for Lifelong learning:**

Graduates of the programme will have sustained interest to learn and adapt to new technology developments to meet the challenging industrial scenarios.

**PEO 5: Motivation to pursue research in Aerospace field:**

Graduates will have interest and strong desire to undertake research-oriented jobs in industries and doctoral studies in Universities.
PROGRAMME SPECIFIC OUTCOMES

**PSO 1:** The postgraduate will become familiar with approach to analysis for Aerospace engineering problems and conversant with methods of solutions.

**PSO 2:** The postgraduate will come well versed with usage of modern techniques, and software tools to design and develop Aerospace systems and products.

**PSO 3:** The postgraduate will excel as an individual as well as team member in design and research teams in universities and Aerospace industries.

**PSO 4:** The postgraduate will become an enthusiast to learn new technologies and methods lifelong in the area of Aerospace engineering and technology.

Mapping of PEOs with POs

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OBJECTIVES:
- To familiarize the students in the field of differential equations.
- To enable them to solve boundary value problems associated with engineering applications using transform methods.
- To expose the students to the concepts of calculus of variations.
- To introduce conformal mappings and their applications to fluid flows and heat flows.
- To give the students a complete picture of tensor analysis.

UNIT I
ALGEBRAIC EQUATIONS

UNIT II
LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS
Laplace transform: Definitions, properties - Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation.

UNIT III
FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS

UNIT I
CALCULUS OF VARIATIONS
Concept of variation and its properties – Euler’s equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries -Direct methods – Ritz and Kantorovich methods.

UNIT V
TENSOR ANALYSIS
Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation – Gradient, divergence and curl.

OUTCOMES:
CO1 On successful completion of the course, the students will be able to
CO2 get familiarized with the methods which are required for solving system of linear, Non linear equations and eigenvalue problems.
CO3 develop the mathematical methods of applied mathematics and mathematical physics
CO4 solve boundary value problems using integral transform methods apply the concepts of calculus of variations in solving various boundary value problems
CO5 familiarize with the concepts of tensor analysis.

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OBJECTIVES:
To impart knowledge on
- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I  RESEARCH PROBLEM FORMULATION  9
Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II  RESEARCH DESIGN AND DATA COLLECTION  9
Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III  DATA ANALYSIS, INTERPRETATION AND REPORTING  9
Sampling, sampling error, measures of central tendency and variation.; test of hypothesis-concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV  INTELLECTUAL PROPERTY RIGHTS  9
Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V  PATENTS  9
Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

COURSE OUTCOMES
Upon completion of the course, the student can
CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

TOTAL: 45 PERIODS

REFERENCES:
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
COURSE OBJECTIVES: This course will enable students
1. Analysis of loads acting on aircraft and spacecraft components
2. Comprehension of design requirements of aircraft and spacecraft
3. Knowledge of the generalized theory of pure bending and an understanding of beam behavior in symmetrical and unsymmetrical bending
4. Ability to carry out shear flow calculations involving aircraft components
5. Exposure to shear flow analysis and design of compression members

UNIT I LOADS ACTING ON AIRCRAFT AND SPACECRAFT

UNIT II DESIGN REQUIREMENTS

UNIT III ANALYSIS OF BEAMS

UNIT IV SHEAR FLOW ANALYSIS
Flexural Shear Flow in Thin-Walled Beams – Equilibrium Equations and Strain-Displacement Relations – Determination of the Shear Centre Position in Open and Closed Sections – Structural Idealization of Wing and Fuselage – Shear Flow due to Combined Bending and Torsion – Torsion of Thin-Walled Sections – Shear Flow in a Thin-Webbed Tapered Beam

UNIT V COMPRESSION MEMBERS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Ability to analyze and calculate static and dynamic loads acting on the structural components of aircraft and spacecraft
CO2 Appreciation and understanding of airworthiness requirements and design procedures
CO3 Skill in carrying out stress and deflection calculations in bending of beams
CO4 Ability to carry out shear flow calculations involving aircraft components
CO5 Knowledge and confidence in designing a compression member for aerospace application

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COURSE OBJECTIVES: This course will enable students
1. Gain knowledge on the basics of low-speed aerodynamics
2. Learn the physics involved in compressible flows.
3. Provide enough knowledge on boundary layers and their interactions.
4. Impart knowledge on the aerodynamic characteristics of missile components.
5. Gain an idea about aerodynamic heating phenomena.

UNIT I   BASICS OF INCOMPRESSIBLE FLOW 12
Aerodynamic forces and moments - Centre of pressure - Aerodynamic centre - Continuity equation - Momentum equation - Stream function - Potential function - Elementary flows - Flow over cylinder, sphere and cones.

UNIT II   COMPRESSIBLE FLOWS 12

UNIT III   BOUNDARY LAYER THEORY 12
Boundary layer thickness - Displacement thickness - Momentum thickness - Laminar boundary layer - turbulent boundary layer - Blasius solution - Skin friction drag estimation - Shock wave- boundary layer interactions.

UNIT IV   AERODYNAMIC CHARACTERISTICS OF MISSILES 12
Airframe components of missiles - Forebody shapes - Prediction of component characteristics - Wing planform for missiles Delta wing - Vortex break down - Compressibility effect on deltawing- Wing-body interference effects - Transonic and Supersonic drag reduction methods – Findrag- Bodydrag.

UNIT V   AERODYNAMIC HEATING 12

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Have through knowledge on the concepts of incompressible aerodynamics.
CO2 Be able to analyse practical problems involving Fanno and Rayleigh flow.
CO3 Have knowledge on the concepts of laminar and turbulent boundary layer flows and their interaction with shock waves.
CO4 Able to demonstrate and analyse different configurations of missiles and their characteristics.
CO5 Be able to design efficient re-entry vehicles by solving the problem of aerodynamic heating.

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COURSE OBJECTIVES: This course will enable students
1. To impart knowledge on the basic concepts of space propulsion.
2. To learn about the physics of ionized gases.
3. To get familiarize with the types of nuclear rockets and the basic concepts of nuclear propulsion systems.
4. To study about the radioisotope propulsion.
5. To realise the importance of advanced space propulsion concepts.

UNIT I INTRODUCTION TO SPACE PROPULSION
Background and Fundamentals of Space propulsion - Classification of Propulsion Systems, Scramjet Propulsion - Scramjet Inlets; Scramjet Performance, Chemical rocket Propulsion-Tripropellants; Metalized Propellants; Free Radical Propulsion, Nuclear Propulsion, Electric Propulsion, Micropropulsion, MEMS and MEMS- Hybrid Propulsion Systems.

UNIT II ELECTRIC PROPULSION
Electric propulsion working principle- Classification of electric propulsion systems- Electrothermal, Electrostatic and Electromagnetic, Resistojet and arcjet concept, Electrostatic – concepts of Ion Thruster, Hall Thruster, Field Emission Thruster, Colloid Thruster, Low power neutralizers concept with diagram, Laser Accelerated Plasma Propulsion, Electromagnetic thrusters types – MPD, PPT, VASIMAR

UNIT III NUCLEAR ROCKET PROPULSION

UNIT IV MICROPROPULSION
Introduction to Micropropulsion - types of Micropropulsion -Micropropulsion Requirements - Mechanism ofSolid Microthrusters, Micro Mono and bi-propellant Thrusters, Cold Gas Thruster - Microchip laser thruster concept - Comparison between Micro Ion Thruster, Low Power Hall Thruster, Micro PPT Thruster, MEMS FEEP/Colloid Thruster and Microchip Laser Thruster

UNIT V ADVANCED SPACE PROPULSION CONCEPTS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Know about different types of Space propulsion
CO2 Have understanding on the classification and working principle of Electric propulsion
CO3 Acquire the knowledge on types of nuclear rockets with their design considerations.
CO4 Learn the basics of micropropulsion and the different types of that with the working concept.
CO5 Know more about the advancements in the space propulsion and their diverse fields of new studies.

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COURSE OBJECTIVES:
1. To gain knowledge on the principles of subsonic and supersonic wind tunnel and their operation
2. To acquire practical knowledge on various aerodynamic principles related to inviscid incompressible fluids.
3. To calculate various aerodynamic characteristics of various objects
4. To characterize laminar and turbulent flows.
5. To get practical exposure on flow visualization techniques pertaining to subsonic flows

LIST OF EXPERIMENTS:
1. Calibration of subsonic wind tunnel.
2. Pressure distribution over a smooth cylinder.
3. Pressure distribution over a rough cylinder.
4. Pressure distribution over a symmetric aerofoil section.
5. Pressure distribution over a cambered aerofoil section.
6. Pressure distribution over a wing of cambered aerofoil section.
8. Wake measurements behind a bluff body.
9. Velocity boundary layer measurements over a flat plate.

Any 10 experiments may be conducted.

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be

CO1 Able to operate and calibrate subsonic and supersonic wind tunnel
CO2 Able to analyse the pressure distribution over the streamlined and bluff bodies
CO3 Able to carry out measurement of force and moments on aircraft models
CO4 Capable of measuring boundary layer thickness over various models.
CO5 Able to carry out flow visualization at subsonic speeds.

LABORATORY EQUIPMENTS REQUIRED
1. Subsonic wind tunnel
2. Rough and smooth cylinder
3. Symmetrical and Cambered aerofoil
4. Wind tunnel balance
5. Schlieren system
6. Pressure Transducers
7. Supersonic wind tunnel
8. Blower
9. Testing models like flat plate, bluff body

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025
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COURSE OBJECTIVES:
1. To practically determine flow behaviour of jets
2. Provides an idea of wall pressure distribution on subsonic and supersonic inlets and nozzles.
3. Perform testing on compressor blades and basic knowledge on cold flow studies.
4. Visualize the shock pattern in supersonic flows
5. Perform experiments on cavity models.

LIST OF EXPERIMENTS
1. Flow visualization of a secondary injection in a supersonic flow
2. Flow visualization of shock system in front of a supersonic inlet
3. Wall pressure measurements in a supersonic nozzle
4. Total pressure measurements along the jet axis of a circular supersonic jet
5. Total pressure measurements in the radial direction of a supersonic circular jet
6. Wall pressure measurements in a supersonic diffuser
7. Cold flow studies of a wake region behind flame holders
8. Wall pressure measurements of a noncircular combustor
9. Wall pressure measurements of a subsonic diffuser
10. Cascade testing of compressor blades.
11. Pressure distribution on cavity model with injections.

TOTAL : 60 PERIODS

COURSE OUTCOMES:
CO1  To apply the basic fundamentals into practical problem in propulsive systems.
CO2  To get practical exposures to internal flow characteristics of compressor and turbine blade passage.
CO3  To demonstrate the fundamental concepts of low speed and high speed jets and experimental investigation through the pressure data.
CO4  To get practical exposures on flow visualization techniques pertaining to supersonic flows.
CO5  To demonstrate the working of supersonic combustor and its flow characteristics.

LABORATORY EQUIPMENTS REQUIREMENTS
1. Supersonic nozzle and supersonic diffuser
2. Total pressure probes
3. Symmetrical Cambered aerofoil
4. Models of flame holders and non circular combustor
5. Traversing mechanism (at least 2-D)
6. Pressure Transducers/ pressure scanner
7. Cascade model for compressor blades
8. Multitube manometers

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COURSE OBJECTIVES: This course will enable students
1. To realise the importance of studying the peculiar hypersonic speed flow characteristics pertaining to flight vehicles.
2. To provide knowledge on various surface inclination methods for hypersonic inviscid flows.
3. To arrive at the approximate solution methods for hypersonic flows.
4. To impart knowledge on hypersonic viscous interactions.
5. To impart knowledge on the effect on aerodynamic heating on hypersonic vehicles.

UNIT I INTRODUCTION TO HYPERSONIC AERODYNAMICS
Importance of Hypersonic flow - Peculiarities of Hypersonic flows – Thin shock layers – entropy layers – viscous Interactions - High temperature flows – low density and high-density flows – hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows – velocity vs altitude map for hypersonic vehicles.

UNIT II SURFACE INCLINATION METHODS FOR HYPERSONIC INVISCID FLOWS

UNIT III APPROXIMATE METHODS FOR INVISCID HYPERSONIC FLOWS

UNIT IV VISCOUS HYPERSONIC FLOW THEORY
Peculiarities of hypersonic boundary layers – boundary layer equations – hypersonic boundary layer theory – Self similar solutions – Flat plate case; Non similar hypersonic boundary layers – Local similarity method and finite difference method – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating.

UNIT V VISCOUS INTERACTIONS AND TRANSITION
Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Parameters affecting hypersonic boundary layer transition – Estimation of hypersonic boundary layer transition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Apply problem-solving techniques to analyze and solve inviscid and viscous hypersonic flow problems.
CO2 Evaluate the impact of high temperature on hypersonic aerodynamics and its effects.
CO3 Generate and assess different solution methods to mitigate aerodynamic heating challenges in hypersonic vehicles.
CO4 Evaluate and analyze design considerations and issues associated with hypersonic vehicles.
CO5 Demonstrate an understanding of the significance and application of relevant equations in modeling viscous hypersonic flows.
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COURSE OBJECTIVES: This course will enable students
1. To introduce special needs for manned space missions and pre calculation of space environment to students.
2. To impart the knowledge on basis concepts of space mechanics like Newton’s law of gravitation and its applications, reference co-ordinate systems and position vs time relationships of celestial bodies.
3. To acquaint students on the methodologies for computation of satellite orbit perturbations
4. To elucidate the concepts of space of influence and its purpose in computing interplanetary trajectories to students.
5. To impart knowledge of various phases of ballistic trajectories and special features of re-entry phase to students also to calculate simple orbital rendezvous and phasing maneuvers.

UNIT I  SPACE ENVIRONMENT

UNIT II  CHARACTERISTICS OF VARIOUS ORBITS

UNIT III  SATELLITE INJECTION AND SATELLITE PERTURBATIONS

UNIT IV  INTERPLANETARY TRAJECTORIES

UNIT V  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

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1  be able to apply the basic knowledge in the calculation of space orbits and the purpose & applications of space missions and identify suitable orbit for a particular mission
CO2  be able to analyze the motion of space objects with time with the choice of using modern computer software tools that would pave the way for igniting the desire to contribute to society

TOTAL: 60 PERIODS
CO3 be able to apply orbit control methods and determine injection errors of satellites by analyzing the orbit and trajectory data using the relevant computer software tools as a member of satellite monitoring team and to create methods and procedures for cost effective and economical approaches to increase the satellite life time which would contribute to the benefit of the society

CO4 be able to perform calculations and analyze the suitability pertaining to trajectories for interplanetary missions with a good grasp in basics of mathematical and physical sciences with the use of modern computer simulation tools

CO5 be able to design and analyse various orbit maneuvers for planetary and interplanetary missions that would inculcate a life-long interest in the subject of space mechanics and help design methods for cost effective solutions
be able to evaluate trajectories required for various defence missions that use missiles by way of identifying and formulating the requirements followed by design and analysis using modern tools for computation as a mission team member

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COURSE OBJECTIVES: This course will enable students
1. To get insights into the basic aspects of various discretization methods.
2. To provide basic ideas on the types of PDE's and its boundary conditions to arrive at its solution.
3. To impart knowledge on solving conductive, transient conductive and convective problems using computational methods.
4. To solve radiative heat transfer problems using computational methods.
5. To provide a platform for students in developing numerical codes for solving heat transfer problems.

UNIT I  INTRODUCTION
Finite Difference Method-Introduction-Taylor’s series expansion-Discretization Methods
Forward, backward and central differencing scheme for first order and second order Derivatives
Types of partial differential equations-Types of errors-Solution to algebraic equation-Direct Method
and Indirect Method-Types of boundary condition-FDM - FEM -FVM.

UNIT II  GOVERNING EQUATIONS FOR FLUID FLOW AND HEAT TRANSFER
Governing Equations in fluid flows-Continuity, momentum and energy equation-turbulence model,
governing equations in conductive heat transfer-Cartesian, cylindrical and spherical co-ordinate,
Governing equations convective- Force and free convection and radioactive heat transfer.

UNIT III  FINITE DIFFERENCE FORMULATION FOR CONDUCTIVE HEAT TRANSFER
General 3D-heat conduction equation in Cartesian, cylindrical and spherical coordinates.
Computation (FDM) of One –dimensional steady state heat conduction –with Heat generation-
without Heat generation- 2D-heat conduction problem with different boundary conditions-
Numerical treatment for extended surfaces- Numerical treatment for 3D- Heat conduction-
Numerical treatment to 1D-steady heat conduction using FEM. Introduction to Implicit, explicit Schemes and crank-
Nicolson Schemes Computation(FDM) of One- dimensional un-steady heat conduction –with heat
Generation-without Heat generation - 2D-transient heat conduction problem with different boundary
conditions using Implicit, explicit Schemes-Importance of Courant number- Analysis for I-D,2-D
transient heat Conduction problems.

UNIT IV  FINITE DIFFERENCE FORMULATION FOR CONVECTIVE AND RADIATIVE HEAT TRANSFER
Convection- Numerical treatment (FDM) of steady and unsteady 1-D and 2-d heat convection-
diffusion steady-unsteady problems- Computation of thermal and Velocity boundary layer flows.
Upwind scheme-Stream function-vorticity approach-Creeping flow. Radiation fundamentals-Shape
factor calculation-Radiosity method- Absorption Method - Montecarlo method-Introduction to Finite
Developing a numerical code for 1D, 2D heat transfer problems.

UNIT V  NUMERICAL APPROACH FOR RADIATIVE HEAT TRANSFER
Introduction, Addition and Subtraction of Two Matrices, Program for Solving M × N Matrix, 5
Jacobi’s Iterative Method for Solving Matrix, Coding for One-Dimensional Heat Condition in a Slab
with Temperature Specified Boundary Condition, Coding for Transient Heat Condition in a Slab with
Temperature Specified Boundary Condition using any one of the programming languages namely C,
c++,MATLAB and Python.
EXPERIMENTS IN CFD

LIST OF EXPERIMENTS:
1. Numerical simulation of 1-D diffusion and conduction in fluid flows
2. Numerical simulation of 1-D convection-diffusion problems
3. Numerical simulation of 2-D unsteady state heat conduction problem
4. Numerical simulation of 2-D diffusion and 1-D convection combined problems
5. Structured grid generation over airfoil section
6. 3-D numerical simulation of flow through CD nozzles

NOTE: Any five experiments will be conducted

TOTAL :  45 PERIODS + 30 Periods

COURSE OUTCOMES:
At the end of this course, students will be able to

CO1 Have an Idea about discretization methodologies for solving heat transfer problems.
CO2 Be able to solve 2-D conduction and convection problems.
CO3 Have an ability to develop solutions for transient heat conduction in simple geometries.
CO4 Be capable of arriving at numerical solutions for conduction and radiation heat transfer problems.
CO5 Have knowledge on developing numerical codes for practical engineering heat transfer problems.

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COURSE OBJECTIVES:
1. Understand the utility of electrical resistance strain gauges
2. An exposure to photo elasticity and its applications in stress analysis
3. Familiarization with practical aspects of symmetrical and unsymmetrical bending of beams
4. Hands-on experience with the fabrication of composite laminates
5. Knowledge in coupon test procedures and non-destructive evaluation of composite materials

LIST OF EXPERIMENTS:
1. Study of Symmetrical Bending of Beams
2. Un symmetrical Bending of Beams
4. Experimental Determination of the Shear Center Position for a Thin-Walled Beam
5. Transmission and Reflection Polariscope Experimental Set-up & Working Principle
6. Fabrication and Calibration of a Photoelastic Specimens
7. Static analysis of a uniform bar subject to different loads - 1-D element
8. Thermal stresses in a uniform and tapered member – 1-D element
9. Static analysis of trusses / frames under different loads
10. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation of discrete, distributed, and user-defined loads
11. Static analysis of a beam with additional spring support
12. Stress concentration in an infinite plate with a small hole
13. Bending of a plate with different support conditions
14. Buckling of solid and thin-walled columns under different end conditions
15. Free vibration analysis of a bar / beam

Any 12 experiments will be conducted from above 15 experiments

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be

CO1 Develop an ability to handle and utilize various engineering instruments
CO2 Confidently and correctly interpret experimental data and correlate with theory
CO3 An understanding of error analysis and the capability to suggest improvisations in experimental procedures
CO4 Familiarization with modern experimental techniques and software tools
CO5 Ability to carry out bending, buckling and vibration tests
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Seminar is to be given by the student after the completion of a mini project chosen by the student. Topics for the mini projects can be from the aeronautical engineering and allied fields. The mini project can be based on either numerical or analytical solution or design or fully experimental; or a combination of these tasks.
COURSE OBJECTIVES:
This course will enable students
1. To learn the satellite mission and configurations,
2. To learn an Electrical power sub system of satellites
3. To learn the attitude and orbit control systems of satellites.
4. To gain knowledge on basics of propulsion systems, structures, and thermal controls of Satellites.
5. To learn the satellite telemetry and telecommand systems.

UNIT I SATELLITE MISSION AND CONFIGURATION 9

UNIT II POWER SYSTEM 9

UNIT III ATTITUDE AND ORBIT CONTROL SYSTEM 9
Coordinate system –AACS requirements–Environment effects – Attitude stabilization – Attitude sensors –Actuators–Orbit Control–Design of control algorithms.

UNIT IV PROPULSION SYSTEMS, STRUCTURES AND THERMAL CONTROL 9

UNIT V TELEMETRY SYSTEMS 9
Base Band Telemetry system– Modulation– TT system–Telecommand system–Ground Control Systems

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Understand the importance of Spacecraft missions and configurations
CO2 Explain Spacecraft power system functions and importance
CO3 Explain spacecraft Attitude and orbital control system design
CO4 Understand satellite propulsion, thermal control and structure subsystems
CO5 Analyse satellite telemetry and telecommand systems

REFERENCES:
2. Lecture notes on “Satellite Architecture”, ISRO Satellite Centre Bangalore – 560 017
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COURSE OBJECTIVES: This course will enable students
1. Applied understanding of material science and significance of material defects
2. Knowledge of how different materials behave in tension, compression and shear
3. Understand the behavior of high-performance alloys for aerospace application
4. Exposure to various types of high temperature materials and their properties
5. Study of different ways in which material failure can take place

UNIT I MATERIAL SCIENCE

UNIT II MECHANICAL BEHAVIOUR

UNIT III METALLIC ALLOYS

UNIT IV HIGH TEMPERATURE MATERIALS

UNIT V MATERIAL FAILURE

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Knowledge of material science and ability to perform theoretical calculations
CO2 Good understanding about the mechanical behavior of metals and other materials
CO3 Ability to correctly choose a suitable metallic alloy for a specific application
CO4 Understanding and appreciation of high temperature materials and their properties
CO5 Knowledge about how material failure can take place and exposure to fracture mechanics

TOTAL: 45 PERIODS
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COURSE OBJECTIVES: This course will enable students
1. Ability to categorise and characterize a conventional sensor.
2. To study accelerometer instruments, frame conversion and its measurements.
3. To study the gyroscope and its types and its application.
4. To study magnetic compass types and GPS systems.
5. To study various power plant measurements related to satellite systems.

UNIT I  ATTITUDE SENSORS  9
Spacecraft sensors – Types, Analog to Digital and Digital to Analog, Resistive, Capacitive, Inductive, Piezoelectric, Magnetostrictive and Hall effect sensors - Static and Dynamic Characteristics of Transducers, Electro optic sensors-Horizon sensor, Earth sensors, sun sensors, star sensor.

UNIT II  ACCELEROMETER AND ITS MEASUREMENTS  9
Accelerometer and its properties, Analog accelerometer, Digital Accelerometer, MEMS, Inertial frame to body frame conversion, Body to inertial frame conversion, Fundamentals of attitude estimation.

UNIT III  GYROSCOPE AND ITS MEASUREMENTS  9
Gyroscope and its properties, gyro system, Gyro horizon, Erection systems for Gyro Horizons- Direction gyro-direction indicator, Rate gyro-rate of turn and slip indicator, Turn coordinator, Digital gyroscopes, MEMS, Ring Laser Gyro (RLG) and Fiber Optic Gyroscope (FOG).

UNIT IV  COMPASS SYSTEMS AND GPS MEASUREMENTS  9
Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator, IRNSS and GPS.

UNIT V  POWER PLANT INSTRUMENTS & FLIGHT DATA RECORDING  9
Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments, exhaust gas temperature, Engine fuel Indicators, engine vibration, monitoring and Flight Data Recording.

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Ability to understand various types of spacecraft sensors.
CO2 Ability to understand the working principle of various accelerometers and their applications.
CO3 Ability to determine and analyze the working of various types of Gyroscope instruments
CO4 Familiarize with the compass system used for satellite applications.
CO5 Ability to understand the working principle of fuel measurement and engine measurement system.

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COURSE OBJECTIVES: This course will enable students
1. To provide knowledge on the basic aspects of space vehicle operation environment.
2. To give an idea about the structural loads acting on space vehicles.
3. To introduce the space vehicle design aspects, its complex issues requiring expertise from many different areas of Aerospace Engineering.
4. To impart knowledge on various parameters that influences the design of space vehicles including their mission, orbital mechanics and the space environment.
5. To get insight into the basic aspects of re-entry motion.

UNIT I LAUNCH VEHICLE BASICS

UNIT II STRUCTURAL DESIGN

UNIT III CONFIGURATION ASPECTS

UNIT IV POWER SYSTEM DESIGN

UNIT V RE-ENTRY MOTION
Re-entry Motion - Trade-offs for Re-entry Design - Significant Forces on a Re-entry vehicle - Ballistic Coefficient - Re-entry Motion Analysis - Trajectory and Deceleration - Trajectory and Heating - Trajectory and the Re-entry Corridor- Vehicle Shape design.

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Familiar with the selection criteria of space launch vehicles
CO2 Able to design space vehicles considering the various structural loads
CO3 In a position to wisely select suitable configuration of space launch vehicle for given Requirements
CO4 Able to perform the design of power system for space vehicles.
CO5 Able to analyze re-entry motion of space vehicles.
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COURSE OBJECTIVES: This course will enable students
1. To introduce the students the governing equations of fluid dynamics in conservative and non-conservative partial differential form and the role of various terms in the equations
2. To expose the students to both structured and unstructured grid generation and the grid generation principles
3. To make the students familiarize with time dependent methods and their applications in engineering problems
4. To introduce the students the basic principles involved in finite volume method and its applications in aeronautics and aerospace engineering
5. To make the students familiarize with the industrial applications of CFD and its role in the design of various components in engineering

UNIT I   GOVERNING EQUATIONS OF FLUID FLOW AND NUMERICAL SOLUTIONS  9
Basic fluid dynamics equations, Equations in general orthogonal coordinate system, Body fitted coordinate systems, mathematical properties of fluid dynamic equations and classification of partial differential equations - Local similar solutions of boundary layer equations with numerical integration and shooting technique. Numerical solution inviscid internal flows such as supersonic nozzle isentropic flows for Mach number distribution - Numerical solutions using Panel methods for external flows.

UNIT II   GRID GENERATION AND ASSESSMENT OF GRID QUALITY  9

UNIT III  TIME DEPENDENT METHODS AND THEIR APPLICATIONS  9
Explicit and Implicit time dependent methods – examples and illustrations - stability aspects - Time split and operator splitting methods - Approximate factorization scheme – Time dependent methods for solution of external flows such as over hypersonic blunt bodies - Unsteady transonic flow around airfoils. Illustration of applications for one dimensional and two dimensional diffusion problems – time dependent method applications for convection and diffusion problems.

UNIT IV   FINITE VOLUME METHOD AND ITS APPLICATIONS  9
Introduction to Finite volume Method – Comparison of Finite Difference Method and Finite volume Method - Different Flux evaluation schemes such as central, upwind and hybrid schemes – Artificial diffusion - Conditions for convergence - Staggered grid approach - Pressure-Velocity coupling - SIMPLE, SIMPLER algorithms - pressure correction equation (both incompressible and compressible forms) - Applications of Finite Volume Method.

UNIT V   INDUSTRIAL APPLICATIONS OF CFD  9
Turbulence modelling for viscous flows, verification and validation of CFD code, application of CFD tools to 2D and 3D configurations - CFD for aerodynamic heating analysis – Coupling of CFD code with heatconduction code, Unsteady flows – Oscillating geometries, Computational aeroelasticity – Coupling of CFD with structural model – CFD software development for aerospace applications- High performance computing for CFD applications – Parallelization of codes – Hardware requirements and parallel computer architecture - domain decomposition method.

TOTAL : 45 PERIODS
COURSE OUTCOMES:
At the end of this course, students will be able to

CO1 To understand the significance of both conservative and non-conservative forms of governing equations for fluid flows

CO2 To apply with diligence the proper boundary conditions for obtaining the solutions for fluid flow solutions

CO3 To analyse the grid quality and assess its suitability for using it for obtaining CFD solutions

CO4 To evaluate the grid generation techniques and grid control methods for obtaining CFD solutions

CO5 To apply suitable time dependent methods with proper numerical schemes for finding solutions either by steady or unsteady approach for aeronautical and aerospace problems

CO6 To evaluate and identify the required flux evaluation schemes while using finite volume methods for numerical solutions

CO7 To understand the importance of parallelization of computer codes and high performance computing for solving large scale aeronautical and aerospace problems

REFERENCES:
COURSE OBJECTIVES: This course will enable students
1. To learn the concept of measurement, error estimation and various sensors used in space applications.
2. To study the different actuators and their application in spacecraft
3. To study the attitude dynamics and orbital disturbances experienced by the spacecraft.
4. To study various satellite stabilization and orbit maneuvers.
5. To study various types of missiles, launch vehicle and their guidance.

UNIT I  ATTITUDE SENSORS
Relative Attitude sensors – Gyroscopes, Frame conversion, Fundamental of attitude estimation
Motion reference Units, Absolute Attitude sensors – Horizon sensor, Orbital Gyrocompass, Earth sensors, sun sensors (Digital and analog), star sensor- Magnetometer.

UNIT II  CONTROL ACTUATORS
Fundamental principles of operation of Thrusters, Actuator Bandwidth, First order system, second order system.
- Momentum Wheel
- Control Moment Gyros
- Reaction wheel
- Magnetic Torques
- Reaction Jets
- Ion Propulsion
- Electric propulsion
- solar sails.

UNIT III  ATTITUDE DYNAMICS, ATTITUDE AND ORBITAL DISTURBANCES
Rigid Body Dynamics - Flexible body Dynamics - Slosh Dynamics - disturbing forces due to Drag, Solar radiation Pressure and forces - Disturbances due to Celestial bodies.

UNIT IV  ATTITUDE STABILIZATION SCHEMES & ORBIT MANEUVERS
Spin Control, Dual spin Control - Gravity gradient technique - Zero momentum system - Momentum Biased system – Reaction wheel control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer, Bielliptical transfer, Station Keeping and Fuel budgeting.

UNIT V  MISSILE AND LAUNCH VEHICLE GUIDANCE
Operating principles and design of guidance laws - homing guidance laws- short range - Medium range and BVR missiles - Trajectory/ Mission planning -Optimal staging, Pitch program optimization, Disturbances in stages separation region, Disturbances in High dynamic pressure region , Launch Vehicle- Introduction - Mission requirements- Implicit guidance schemes - Explicit guidance - Q guidance schemes

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Get a basic idea of the working principles of attitude sensors and their applications.
CO2 Familiarize with control actuators used for satellite applications.
CO3 Comprehend the application of rocket vehicle guidance laws.
CO4 Demonstrate satellite orbit stabilization schemes and methods of satellite orbit transfer.
CO5 Familiarize with orbit maneuvers of satellites and rocket vehicle guidance.
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COURSE OBJECTIVES:
This course will enable students
1. To impart knowledge to students on basic launch vehicle configurations and preliminary drag estimation
2. To introduce slender and blunt body aerodynamics, aerodynamic aspects of launching phase.
3. To analyse the aerodynamic characteristics of slender and blunt bodies.
4. To provide idea about the missile configurations and preliminary drag estimation.
5. To demonstrate the stability aspects of missile configuration and various control methods of missiles.

UNIT I  BASICS OF HIGH SPEED AERODYNAMICS  9
Compressible flows-ISENTROPIC relations-mathematical relations of flow properties across shock and expansion waves-fundamentals of Hypersonic Aerodynamics

UNIT II  LAUNCH VEHICLE CONFIGURATIONS AND DRAG ESTIMATION  9
Types of Rockets and missiles-various configurations-components-forces on the vehicle during atmospheric flight-nose cone design and drag estimation

UNIT III  BASICS ASPECTS OF MISSILE AERODYNAMICS  9
Classification of missiles-Aerodynamics characteristics and requirements of air to air missiles, air to surface missiles and surface to air missiles-Missile trajectories

UNIT IV  AERODYNAMICS OF SLENDER AND BLUNT BODIES  9
Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aeroelastic effects.

UNIT V  STABILITY AND CONTROL OF MISSILES  9

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 To apply the concepts of high speed aerodynamics on missiles and launch vehicles
CO2 To acquire knowledge on aerodynamics characteristics of missiles of various types
CO3 To estimate drag for various missile configurations and methods to reduce it.
CO4 To estimate the forces and moments acting on missiles.
CO5 To apply slender body aerodynamics knowledge during launching phase and stability and control aspects of missiles.

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COURSE OBJECTIVES: This course will enable students
1. To learn about the concepts of Spacecraft Navigation Guidance and Control subsystems and understand their significance
2. To know the operating principle of various sensors and actuators
3. To have an exposure on various Navigation systems such as Inertial Measurement systems and Satellite Navigation
4. To study longitudinal dynamics and to design the longitudinal autopilot
5. To study about the Relative Navigation Systems
6. To understand the Attitude dynamics and Stabilization Control system

UNIT I     INTRODUCTION  9

UNIT II    ATTITUDE SENSORS AND CONTROL ACTUATORS  9
Orbit sensors - Attitude sensors - Inertial sensors - Electro-optical sensors - Altimeters - Reaction Wheels - Magnetic Torquers - Thrusters - Star Trackers - Magnetometers - Sun Sensors

UNIT III   INERTIAL NAVIGATION SYSTEMS AND GPS  9

UNIT IV    RELATIVE NAVIGATION SYSTEMS  9

UNIT V     ATTITUDE DYNAMICS AND STABILIZATION SCHEMES  9
Rigid Body Dynamics - Flexible body Dynamics - Slosh Dynamics - Drag - Pressure Spin - Dual spin - Gravity gradient - Zero momentum system - Momentum Biased system - Reaction control system - Single and Multiple Impulse orbit Adjustment - Hohmann Transfer – Introduction to Digital Fly-by-wire control - Modern spacecraft GNC

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Understand and Apply the concepts of Spacecraft Navigation Guidance and Control subsystems
CO2 Explain the principle of operation various sensors and actuators and their significances
CO3 Explain the principle of operation of Inertial Measurement systems and Satellite Navigation.
CO4 Understand Relative Navigation system and Rendezvous & Docking concepts
CO5 Explain the Attitude dynamics and Stabilization and FBW Control system

TOTAL : 45 PERIODS
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COURSE OBJECTIVES: This course will enable students
1. An understanding of the importance of composite materials in aerospace application
2. Knowledge of the behaviour of unidirectional composites under longitudinal and transverse loading
3. Understanding about the micromechanics and macromechanics aspects of unidirectional composite materials
4. Familiarization with the classical lamination theory
5. Student would understand different fabrication processes involving composite materials

UNIT I COMPOSITE MATERIALS IN AEROSPACE APPLICATION 9

UNIT II BEHAVIOUR OF UNI-DIRECTIONAL COMPOSITES 9

UNIT III MACROMECHANICS APPROACH 9

UNIT IV CLASSICAL LAMINATION THEORY 9

UNIT V COMPOSITE BEAMS 9

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Knowledge of the properties and advantages of composite materials for aerospace application
CO2 Solve problems related to micromechanics and macro mechanics aspects of composite materials
CO3 Ability to carry out lamina stress analysis and apply different failure theories
CO4 Understand classical lamination theory and ability to design a laminate
CO5 Awareness of the different production methods involving composite parts
REFERENCES:
COURSE OBJECTIVES: This course will enable students
1. Understand the fundamental principles of nuclear physics and their application to aerospace propulsion systems.
2. Develop a comprehensive understanding of nuclear reactor theory and its relevance to aerospace engineering.
3. Explore the design, performance, and safety considerations of nuclear propulsion technologies.
4. Understand the principles of radiation shielding, containment, and safety regulations in nuclear propulsion.
5. Gain insights into the future prospects and challenges of nuclear propulsion in aerospace.

UNIT I INTRODUCTION TO NUCLEAR PROPULSION 9
Historical overview of nuclear propulsion in aerospace - Basic principles of nuclear physics - Fundamentals of nuclear reactions and radioactivity - Overview of nuclear propulsion concepts and their advantages

UNIT II NUCLEAR REACTOR THEORY 9
Principles of nuclear fission and fusion reactions - Neutron physics and reactor kinetics - Types of nuclear reactors and their characteristics - Nuclear fuel cycle and management

UNIT III NUCLEAR PROPULSION TECHNOLOGIES 9
Nuclear thermal rockets (NTR) - Nuclear electric propulsion (NEP) - Project Orion and other advanced concepts - Comparison of different nuclear propulsion technologies

UNIT IV SAFETY AND ENVIRONMENTAL CONSIDERATIONS 9
Radiation shielding and containment - Nuclear safety principles and regulations - Environmental impact assessment - Waste management and disposal strategies

UNIT V FUTURE PROSPECTS AND CHALLENGES 9
Current research and development in nuclear propulsion - Challenges and limitations of nuclear propulsion - Policy and regulatory considerations - Future trends and potential applications

TOTAL: 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to:
CO1 To explain the historical significance and evolution of nuclear propulsion in aerospace engineering and to demonstrate a solid understanding of the fundamental principles of nuclear physics and their relevance to propulsion systems.
CO2 To describe the principles of nuclear fission and fusion reactions and their role in nuclear reactors and to apply neutron physics and reactor kinetics principles to analyze and evaluate reactor performance.
CO3 To compare and contrast different nuclear propulsion technologies based on their performance and efficiency.
CO4 To assess and implement radiation shielding and containment strategies in the design of nuclear propulsion systems and to evaluate the environmental impact of nuclear propulsion systems and propose appropriate mitigation measures.
CO5 To analyze the current research and development activities in nuclear propulsion and to identify the challenges and limitations associated with the practical implementation of nuclear propulsion technologies.
REFERENCES:
COURSE OBJECTIVES: This course will enable students

1. To impart knowledge on the different concepts and Laws related to planetary motion and space mechanics.
2. To impart knowledge on satellite orbit transfer and factors affecting satellite life time
3. To impart knowledge on rocket motion and analytical methods related to rocket motion for different conditions.
4. To impart knowledge on rocket aerodynamics and how it varies with Mach number.
5. To impart knowledge on different methods of rocket control and methods of staging and stage separation in rockets.

UNIT I ORBITAL MECHANICS


UNIT II SATELLITE DYNAMICS


UNIT III ROCKET MOTION

Principle of operation of rocket motor – thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical, inclined and gravity turn trajectories – determinations of range and altitude – simple approximations to burnout velocity.

UNIT IV ROCKET AERODYNAMICS


UNIT V STAGING AND CONTROL OF ROCKET VEHICLES

Need for multi staging of rocket vehicles – Types of Multi staging – multistage vehicle optimization – stage separation dynamics and separation techniques- Aerodynamic and jet control methods of rocket vehicles – SITVC.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of this course, students will be able to

CO1 To explain the fundamental laws of orbital mechanics and will be able to analyse the two and three body problems
CO2 To calculate orbital parameters and perform conceptual trajectory designs for geocentric or interplanetary missions.
CO3 To evaluate the planar motion of rockets for different flight conditions.
CO4 To evaluate the forces and moments acting on airframe of a missile.
CO5 To conceptually design an optimal multistage rocket and compare different methods of stage separation.

TOTAL: 45 PERIODS
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### COURSE OBJECTIVES:
This course will enable students

1. To classify the rockets and can develop the thrust equation.
2. To impart knowledge to the students on solid, liquid and hybrid rocket propulsion.
3. To provide knowledge on the types of igniters and injectors used in solid and liquid rocket systems.
4. To conduct various rocket testing and to analyze various modes of combustion instabilities.
5. To describe and understand types of rocket testing, safety and environmental concerns

#### UNIT I | ROCKET PERFORMANCE
---
Classification of Rockets - Propellants classification - Thrust equation, specific impulses, total impulse, characteristic velocity – Thrust coefficient – Efficiency: Real and ideal nozzle characteristic, Adiabatic flame temperature and its calculation, Criterion for Choice of propellants- flight performance of a rocket vehicle- flight trajectory of a single stage rocket vehicle

#### UNIT II | SOLID ROCKET MOTORS
---
Viscous subsystems of solid rocket motor and their function – Igniters - Type of igniters – Internal ballistics properties-- Burning rate - Factor affecting burning rate - Equilibrium Chamber pressure– Propellant grain geometry design, Erosive burning – Pressure vs Time curve- thrust vs time curve – Special problems of solid rocket nozzle – Combustion mechanism of solid propellants – Solid rocket motor design.

#### UNIT III | LIQUID ROCKET ENGINES
---

#### UNIT IV | HYBRID PROPULSION SYSTEM
---
Standard and reverse hybrid rocket – Application – Limitation - Advanced fuel – Combustion mechanism of hybrid rocket – Regression rate measurement – Methods for improving regression rate - composite propulsion

#### UNIT V | ROCKET TESTING AND COMBUSTION INSTABILITIES
---
Burning rate measurement techniques - Rocket testing – Static testing of rockets – Instrumentation and safety procedures – Ignition delay testing – Combustion instability - L* instability – different modes of combustion instability – Bulk and wave mode of combustion instability in solid and liquid rockets – Pogo instability.

**TOTAL : 45 PERIODS**

### COURSE OUTCOMES:
At the end of this course, students will be able to

- **CO1**: To identify the rocket propulsion system and its applications.
- **CO2**: Analyze the performance of thrust chambers.
- **CO3**: Describe and classify solid propellant rocket motors and its components.
- **CO4**: Analyze propellants properties and associated physical and chemical processes
- **CO5**: Describe and classify liquid propellant rocket motors, its components and various associated systems.

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COURSE OBJECTIVES:
Of this course are
1. To acquaint students with the need for systems engineering and the different process involved in systems engineering
2. To impart knowledge on different phases of development process and design drivers in different phases.
3. To impart knowledge on evolution of avionics architecture and systems integration in spacecraft.
4. To familiarise students with varying system configurations and their compatibility with system evolution.
5. To impart knowledge on system reliability by analysing fault and failure of spacecraft systems and types of maintenance.

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING

UNIT II DESIGN AND DEVELOPMENT PROCESS
Product Life Cycle –Concept Phase-Definition Phase-Design Phase-Build, Test, Operate and Disposal Phase-Whole Life Cycle Tasks- Systems Analysis- Design Drivers in the Project, Product, Operating Environment- Interfaces with the Subsystems.

UNIT III SYSTEM ARCHITECTURES AND INTEGRATION

UNIT IV PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL

UNIT V SYSTEMS RELIABILITY AND MAINTAINABILITY
Systems and Components-Analyses-Influence, Economics, Design for Reliability- Availability - Fault and Failure Analysis, FTA, FMEA - Case Study-Maintenance Types-Program-Planning and Design.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, Students will be able to
CO1 Explain the importance of systems engineering and different process involved in systems engineering
CO2 Explain the different phases of development process and discuss on different factors affecting development process.
CO3 Select a suitable avionics architecture for system integration based on design requirements.
CO4 Design a compatible system by analysing the different factors affecting the compatibility.
CO5 Explain the importance of reliability and different methods of analysing fault and failures to provide system maintenance.
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COURSE OBJECTIVES: This course will enable students
1. To make students familiarize with various types of space missions and their challenges
2. To make students understand the peculiarities of space environment which satellites and astronauts have to encounter for various space missions
3. To expose the students the challenges posed by manned space missions and how to meet them
4. To make students familiarize with planning procedures for successful space missions
5. To expose the students the command, control and communication architecture and the unique nature of technologies required for space missions

UNIT I INTRODUCTION TO MANNED SPACE MISSIONS
Manned vs. unmanned missions – Objectives of manned space missions - Peculiarities and engineering challenges for manned space missions – Space capsules and Space station - Moon and Mars missions - Scientific and technological gains from manned space programs –Reusable space vehicles for manned space missions – Additional requirements for manned space missions – space medicine- microgravity

UNIT II EFFECT OF SPACE ENVIRONMENT ON MANNED SPACE MISSIONS

UNIT III SUPPORT SYSTEMS FOR MANNED SPACE MISSIONS

UNIT IV PLANNING AND LOGISTIC REQUIREMENTS
Planning requirements at various levels – Resources and mission requirements mapping - Ground Communication and Support –Design and planning of Space Mission in terms of Rockets and Launch Vehicles - Mission planning with Orbital Selection and Astrodynamics- Entry, Descent, Landing, and Ascent, Designing and Sizing Space elements – Logistics with respect to Transfer, Entry, Landing, and Ascent Vehicles – Surface Base Design, Sizing, and Integration –Logistic considerations in the operation of Planetary Surface Vehicles

UNIT V SUPPORT TECHNOLOGIES FOR MANNED SPACE MISSIONS
A brief introduction to additional technology requirements for manned space missions - Technology requirements for Mission Operations for Crewed Spaceflight– Role of Space Robotics in manned space missions – Recent developments in technical knowhow for AttitudeDetermination and Control for manned space platforms - Power Systems, command, control and communications for manned space platforms - Extravehicular Activity (EVA) Systems

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 To understand the detailed mission requirements for manned space missions and the challenges posed by such missions
CO2 To evaluate and understand the role of complex phenomena such as microgravity and the importance of space medicine for manned space missions
CO3 To analyse the unique nature of and various effects of cosmic radiation on space environment and apply this knowledge in the design and planning of manned space missions
CO4 To understand and evaluate the intricacies of challenges involved in manned space missions and the human factors such as space adaptation syndrome and the ways to meet them

TOTAL : 45 PERIODS
CO5 To apply space mission planning principles and procedures and also the logistic considerations in the operation of planetary surface vehicles

CO6 To understand the required critical technologies involved in manned space missions and evaluate and apply them in designing human/machine interactions and space robotics

REFERENCES:
2. Eckart, P. “Spaceflight Life Support and Biospherics:5”, Space Technology Library, 2010
AL3054  HIGH SPEED JET FLOWS  L T P C

3 0 0 3

COURSE OBJECTIVES: This course will make students
1. To get insight into the basic aspects of jets and types of jets.
2. To learn the basic properties of jets and its characteristics.
3. To get knowledge on various active and passive jet control methods.
4. To gain knowledge into the basic aspects of jet acoustics.
5. To acquire in-depth knowledge on how and what type of control methods can be implemented practically.

UNIT I  INTRODUCTION

UNIT II  TYPES OF JETS

UNIT III  ACTIVE JET CONTROL METHODS
Active control methods- Actuators-Fluidic, Thermal, Acoustic, Piezoelectric, Electromagnetic, MEMS, Synthetic Jets, Controls and Sensors, Active controls techniques by air tabs - applications.

UNIT IV  PASSIVE JET CONTROL METHODS
Passive control techniques- Tabs, Grooves, Chevrons, non-circular nozzles, Notches and wires, vortex generators and physics of their jet characterizers. Optical Flow Visualization, Applications.

UNIT V  JET ACOUSTICS

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, students will be able
CO1 To acquire knowledge on the unique features of jet flows.
CO2 To analyse the characteristics of jets.
CO3 To have through knowledge on active and passive control methods of jets.
CO4 To acquire knowledge on jet acoustics and methods for suppression of jet noise.
CO5 To demonstrate various experimental techniques to determine jet characteristics.

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COURSE OBJECTIVES: This course will enable students

1. To get familiarize with the basic the operating principles of the various electrical thrusters.
2. To learn the concept of plasma kinetic theory
3. To gain idea on the elements of gas kinetics.
4. To impart knowledge on the classes of MPD thrusters.
5. To study the importance of electric propulsion for space applications.

UNIT I  PHYSICS OF IONIZED GAS
Particle collision in ionized gas - Electron-Atom collision, Electron ion collision, Electron –Electron and ion-Ion collision, Atom-Atom collision and ion atom collision.

UNIT II  BASIC PHYSICS OF ELECTRIC PROPULSION
Historical outline - Definition of Electric Propulsion - High impulse Space Missions - Exhaust velocity and specific impulse - Power supply penalty - Electric charges and Electrostatic fields - Currents and Magnetic interactions - Time dependent fields and Electromagnetic wave propagation.

UNIT III  ELECTRO-THERMAL ACCELERATION
One dimensional model - Enthalpy of high temperature gases - Frozen flow efficiency – Resistojets - Electrical discharges - Arc jets - Operation and Analysis - Materials - advantages and Disadvantages

UNIT IV  ELECTROSTATIC ACCELERATION
One dimensional space-charge flows - Basic relationships - The acceleration- deceleration concept - Ion engines - Design and Performance - Hall effect – Hall thrusters - Field emission electric propulsion (FEEP) - Colloid thrusters

UNIT V  ELECTROMAGNETIC ACCELERATION
The Lorentz force – Magneto gas dynamic channel flow - Ideal steady flow acceleration - Thermal and viscous losses - Geometry considerations - Self-induced fields - Sources of the conducting gas - The magneto plasma dynamic arc - Magneto plasma dynamic (MPD) thrusters - Pulsed plasma acceleration - Pulsed plasma thrusters (PPT) - Quasi steady acceleration - Pulsed inductive acceleration - Travelling wave acceleration, Circuit analysis of pulsed acceleration, coaxial guns and punched acceleration.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to

CO1  Able to classify and describe the electric thrusters for space applications.
CO2  Able to perform the preliminary sizing of a test facility for electric propulsion.
CO3  Able to perform calculations of first approximation on plasmas of electric propulsion.
CO4  Able to set theory models for the study of electric propulsion systems.
CO5  Able to acquire knowledge on the basics of rarefied gas dynamics and plasma physics.

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COURSE OBJECTIVES:
1. To get basic idea on the fundamentals of structural health monitoring.
2. To impart knowledge in the areas of vibration based techniques in structural health monitoring, fibre optics and piezo electric sensors
3. To gain knowledge on the fundamentals of fabrication, modelling, analysis, and design of smart materials and structures
4. To get exposed to the state of the art of smart materials and systems,
5. To impart knowledge on spanning piezoelectrics, shape memory alloys, electro active polymers, mechanochromic materials and fibre optics

UNIT I  INTRODUCTION OF STRUCTURAL HEALTH MONITORING  

UNIT II  OVERVIEW OF SMART MATERIALS  

UNIT III  SMART COMPOSITES  

UNIT IV  INTELLIGENT SYSTEMS AND NEURAL NETWORKS  

UNIT V  ADVANCES IN SMART STRUCTURES & MATERIALS  

TOTAL : 45 Periods
**COURSE OUTCOMES:**

CO1  To familiarize with the fundamentals of history of SHM.

CO2  To provide a systematic approach to SHM process.

CO3  To have knowledge of the various smart materials used for aerospace applications.

CO4  To familiarize with the non-destructive test techniques relevant to SHM.

CO5  To provide hands-on experience with experimental modal analysis

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COURSE OBJECTIVES: This course will enable students
1. To impart knowledge on the basic aspects of UAV and its types.
2. To realize the importance of airframe designs and types of propulsions in unmanned aerial vehicle.
3. To gain knowledge on various subsystems and testing procedure of an unmanned aerial vehicle.
4. To enhance the knowledge in the field of real time applications.
5. To get familiarize with the ground control procedures and operations.

UNIT I  INTRODUCTION TO UAV
History of UAV – classification – basic terminology - models and prototypes – applications

UNIT II  BASICS OF AIRFRAME

UNIT III  DEVELOPMENT OF UAS SYSTEM

UNIT IV  DEPLOYMENT OF UNMANNED AERIAL SYSTEM

UNIT V  COMMUNICATION PAYLOADS AND PATHPLANNING
Payloads – Telemetry – tracking – Aerial photography, Frequency range – Commands – Control, FPV videos – Flight computer sensor – displays, RF modems, Simulation and ground testing, Trouble shooting, waypoints navigation and ground control software.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 To classify UAVs based on different parameters
CO2 To demonstrate ability to design an efficient structure for an UAV of specific application.
CO3 To perform ground testing of UAVs.
CO4 To apply the knowledge gained on electronic intelligence and target designation for successful development of UAS.
CO5 To understand the basic concepts in the different types of navigation schemes for UAS.
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COURSE OBJECTIVES: This course will enable students
1. To make students understand the fundamental physics behind the high temperature gas dynamics
2. To introduce students the fundamentals of statistical thermodynamics and its role in understanding the nature of high temperature flows
3. To expose the students the chemical kinetic theory behind the high temperature effects and the nature of chemical equilibrium in high temperature air
4. To introduce the governing equations for equilibrium and non equilibrium inviscid high temperature flows
5. To explain to the students the role of transport properties in controlling the phenomena such as radiation and diffusion in high temperature gases

UNIT I INTRODUCTION TO HIGH TEMPERATURE FLOWS
Basics of high temperature flows – Important phenomena associated with high temperature flows - Chemical effects in high temperature air – Real and perfect gases – Concept of Gibb’s free energy-entropy changes in chemical and non chemical equilibria – Chemically reacting mixtures – presence of chemically reacting boundary layers

UNIT II ROLE OF STATISTICAL THERMODYNAMICS
Introduction to statistical thermodynamics – Relevance of high temperature effects in hypersonic flow – Role of statistical thermodynamics in understanding the effects of high temperature in hypersonic flows – Applications of statistical thermodynamics - Microscopic description of gases – Boltzmann distribution – Cartesian function.

UNIT III CHEMICAL KINETIC ASPECTS IN HIGH TEMPERATURE FLOWS
Description of Chemical equilibrium in high temperature air and gases – Procedure for calculation of equilibrium composition of high temperature air – Determination of equilibrium properties of high temperature air – Concepts of collision frequency and mean free path – Role of velocity and speed distribution functions

UNIT IV PHENOMENA IN INVISCID HIGH TEMPERATURE FLOWS
Nature of Equilibrium and non equilibrium flows – Governing equations and solution methods for inviscid high temperature equilibrium flows – Properties of equilibrium normal and oblique shock wave flows – Outcome of results on the approximation of frozen and equilibrium flows – Salient features of equilibrium conical and blunt body flows – Governing equations for non equilibrium in viscid high temperature flows

UNIT V TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES
Transport coefficients and nature of their variation with temperature- mechanisms of diffusion – Concept of total thermal conductivity – transport characteristics for high temperature air – radiative transparent gases – radiative transfer equation for transport, absorbing and emitting – equations for absorbing gases

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 To understand the basic physics behind the high temperature flows and will apply the knowledge to account for real gas effects in high temperature flows in aerospace applications
CO2 To analyse the differences between perfect gas flows and real gas flows under high temperature effects
CO3 To understand the relevance of statistical thermodynamics in high temperature flows and also the need for applying the principles of high temperature gas effects in hypersonic flows
CO4 To apply principles of statistical thermodynamics and understand the microscopic description of gases
CO5 To evaluate the equilibrium properties of high temperature air and apply the principles of chemical kinetic theory for calculation of chemical equilibrium composition of gases at high temperature

CO6 To evaluate and analyze the results from equilibrium and frozen flows of inviscid high temperature air flows

CO7 To understand the importance of radiative transport gases and apply the knowledge in the analysis of high temperature gas flows

REFERENCES:
COURSE OBJECTIVES: This course will enable students

1. Basic understanding of different methods of analysis for the solution of static structural problems
2. Knowledge of how finite element equations are formulated
3. An understanding of how characteristic matrices are generated
4. Exposure to different finite elements and awareness of element capability
5. Learning the assembly of finite element equations and solving for unknowns

UNIT I BASIC PROCEDURE

UNIT II 1-D STRUCTURAL ANALYSIS

UNIT III FLEXURE ELEMENTS

UNIT IV TWO DIMENSIONAL PROBLEMS

UNIT V FIELD PROBLEMS

TOTAL: 60 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to

CO1 Ability of the student to understand and apply Rayleigh-Ritz, Galerkin and finite difference solution techniques to different problems

CO2 Knowledge and application of the finite element method to static structural problems involving bar, beams and trusses

CO3 Ability to frame the nodal load vector using the principle of work equivalence

CO4 Student would be able to solve planar problems using the finite element method

CO5 Ability of the student to solve 1-D and 2-D heat transfer problems
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COURSE OBJECTIVES:
1. Theoretical knowledge in the concepts of micromechanics and macromechanics
2. Understand the mathematical equations governing the behavior of composite plates
3. Study and understand the classical lamination theory and analyze the behavior of composite laminates
4. Understand the behavior of special laminates and knowledge of how laminated beams and plates should be designed
5. Knowledge of methods of characterization and non-destructive evaluation

UNIT I BEHAVIOUR OF A UNI-DIRECTIONAL LAMINA

UNIT II CLASSICAL LAMINATION THEORY

UNIT III ANALYSIS OF LAMINATED BEAMS AND PLATES

UNIT IV DESIGN OF COMPOSITE STRUCTURES
Design of Special Laminates (Symmetric, Anti-symmetric, Balanced and Quasi-Isotropic) – Mathematical Analysis – Design Outline and Procedure – Possible Modes of Failure – Failure Analysis – Design Examples – Composite Stiffener Design – Laminate Design for Strength – Design for Stiffness – Composite Panel Subject to In-Plane and Combined Loading

UNIT V CHARACTERIZATION AND NON-DESTRUCTIVE EVALUATION

TOTAL : 45 Periods

COURSE OUTCOMES:
CO1 Ability to perform theoretical calculations in the micromechanics and macromechanics aspects of a composite lamina
CO2 Sound understanding of the applications of the classical lamination theory
CO3 Ability to design a composite laminate including special laminates
CO4 Good understanding of the possible failure modes of composite beams plates
CO5 Skill in carrying out characterization and non-destructive evaluation studies involving composite materials
REFERENCES:
COURSE OBJECTIVES:
1. To develop a deep understanding of the principles and technologies related to hypersonic flows and propulsion.
2. To explore the design considerations and challenges associated with ramjet propulsion systems.
3. To explore the design considerations and challenges associated with scramjet propulsion systems.
4. To examine the characteristics and design principles of rocket-based hypersonic propulsion.
5. To equip students with the knowledge and skills required for hypersonic vehicle design and testing.

UNIT I INTRODUCTION TO HYPERSONIC FLOWS AND PROPULSION 9
Overview of hypersonic flight and its significance - Characteristics of hypersonic flows: compressibility effects, shock waves, and boundary layer behavior - Thermodynamics of high-temperature gases and their impact on hypersonic propulsion - Review of basic gas dynamics and aerothermodynamics - Introduction to hypersonic propulsion systems and their challenges

UNIT II RAMJET PROPULSION 9
Operating principle - Sub critical, critical and supercritical operation - Combustion in ramjet engine - Turbo Ramjet - Ramjet performance - Dual mode Ramjet (DMRJ) - Integral ram-rocket - Sample ramjet design calculations - Numerical problems

UNIT III SCRAMJET PROPULSION 9

UNIT IV ROCKET-BASED HYPERSONIC PROPULSION 9
Rocket engines for hypersonic flight: solid and liquid propulsion systems - Thrust augmentation methods for hypersonic rockets - Combustion processes in high-speed rocket engines - Nozzle design and optimization for hypersonic propulsion - Propellant choices and their impact on performance

UNIT V HYPERSONIC VEHICLE DESIGN AND TESTING 9
Hypersonic vehicle design considerations: aerodynamics, propulsion, structures, and controls - Multi-disciplinary optimization for hypersonic vehicle design - Hypersonic wind tunnel testing and experimental techniques - Hypersonic testing facilities and capabilities - Challenges and future directions in hypersonic vehicle design and testing

TOTAL: 45 Periods
COURSE OUTCOMES: Upon completion of the course, students will be able

CO1 To describe the characteristics of hypersonic flows, analyze the impact of compressibility effects and shock waves, and discuss the challenges and future applications of hypersonic technology.

CO2 To explain the working principles and performance characteristics of Ramjet engines, analyze design considerations of ramjet and dual mode ramjet engines.

CO3 To explain the working principles and performance characteristics of scramjet engines, analyze design considerations for hypersonic intakes and compression systems, and evaluate the challenges involved in scramjet propulsion.

CO4 To differentiate between different rocket propulsion systems for hypersonic flight, analyze combustion processes in high-speed rocket engines, and evaluate the design and optimization of rocket nozzles for hypersonic propulsion.

CO5 To integrate knowledge from various disciplines to design hypersonic vehicles, analyze the multi-disciplinary optimization process, apply experimental techniques for hypersonic vehicle testing, and assess the challenges and future directions in hypersonic vehicle design.

REFERENCES:
COURSE OBJECTIVES: This course will enable students

1. To make students familiarize about Remote sensing Technology
2. To impart knowledge on UAV in Survey and Mapping applications
3. To gain knowledge of the Geospatial Data Base Creation
4. To introduce the basic concepts of Drone Data Analysis
5. To impart knowledge on Drone in Mapping applications

UNIT I REMOTE SENSING TECHNOLOGY

UNIT II DRONE SURVEY AND MAPPING
Principles of Data acquisition, Comparison of Tradition survey with Advanced Survey Techniques, Challenges in Data Capturing, Data Capturing Methodology, DGPS – GCP Importance, GCS Overviews, Flight Plan, Auto Mission, Advantages and limitation of Drones in Mapping.

UNIT III GEOSPATIAL DATA BASE CREATION

UNIT IV GEOSPATIAL DATA ANALYSIS
Introduction of Analysis Software, Input spatial data into GIS, Conversion of Data, Accuracy Assessment, Analysis of 2D and 3D Data Products, Importance of Data Analysis, Data Management, Case Study on Drone Data Analysis, WebGIS.

UNIT V CASE STUDIES
Drones in Disaster, Agriculture, Mining, Urban Planning, Construction and Infrastructure, Environmental Mapping, Archaeological, Rehabilitation and reconstruction - Drones in Future Mapping Applications.

COURSE OUTCOMES:
At the end of this course, students will be able to

CO1 Explain the Remote Sensing Technology.
CO2 Execute Drone flight plan, data capturing and its challenges
CO3 Explain the Advanced Drone data processing
CO4 Describe the Drone Data Interpretation
CO5 Develop Drone based Applications and Impacts

TOTAL : 45 PERIODS
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COURSE OBJECTIVES: This course will enable students
1. To familiarize students with the historical context, current agencies, and key concepts related to space exploration.
2. To provide students with an understanding of the essential systems and technologies used in space exploration missions.
3. To explore the history, challenges, and future prospects of human space exploration.
4. To introduce students to the world of unmanned missions and robotic exploration of celestial bodies.
5. To explore the various challenges and future possibilities in the field of space exploration.

UNIT I  INTRODUCTION TO SPACE EXPLORATION  9
History of Space Exploration: From ancient observations to the Space Age- Overview of Current Space Agencies and their Missions- The Space Environment: Celestial bodies, gravity, and vacuum- Motivations for Space Exploration: Scientific, technological, and societal perspectives- Spacecraft and Mission Architectures: Design considerations and mission planning

UNIT II  SPACECRAFT SYSTEMS AND TECHNOLOGIES  9

UNIT III  HUMAN SPACEFLIGHT  9

UNIT IV  ROBOTIC EXPLORATION  9
Unmanned Missions: Lunar probes, Mars rovers, and beyond- Planetary Science: Studying other celestial bodies- Remote Sensing and Imaging: Gathering data from distant objects-Sample Return Missions: Challenges and scientific importance-Future Trends in Robotic Space Exploration

UNIT V  SPACE EXPLORATION CHALLENGES AND FUTURE PROSPECTS  9
Space Debris and Environmental Concerns- Interplanetary Travel: Advanced propulsion concepts-Space Tourism: Opportunities and challenges-Colonizing Other Worlds: Habitats and sustainability-Future Space Missions and Exploration Initiatives

TOTAL : 45 PERIODS

COURSE OUTCOMES:
At the end of this course, students will be able to
CO1 Demonstrate an understanding of the history and motivations behind space exploration.
CO2 Explain the fundamental principles of rocket propulsion and spacecraft subsystems.
CO3 Analyze the challenges and advancements in human space exploration.
CO4 Evaluate the significance and challenges of robotic exploration in space.
CO5 Discuss the major challenges and future prospects in the field of space exploration.
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COURSE OBJECTIVES:
To impart knowledge to the students and basic principles of combustion, types of flames and also make them familiarize the combustion process in gas turbine, ramjet, scram jet and rocket engines.

UNIT I  THERMODYNAMICS OF COMBUSTION  9
Stoichiometry – absolute enthalpy- enthalpy of formation- enthalpy of combustion- laws of thermochemistry- pressure and temperature effect on enthalpy of formation, adiabatic flame temperature, chemical and equilibrium products of combustion.

UNIT II  PHYSICS AND CHEMISTRY OF COMBUSTION  9

UNIT III  PREMIXED AND DIFFUSED FLAMES  9

UNIT IV  COMBUSTION IN GAS TURBINE, RAMJET AND SCRAMJET  9
Combustion in gas turbine chambers, recirculation, combustion efficiency, flame holders, subsonic combustion in ramjet, supersonic combustion in scramjet. Subsonic and supersonic combustion controlled by decision mixing and heat convection.

UNIT V  COMBUSTION IN CHEMICAL ROCKET  9

COURSE OUTCOMES:
Upon completion of the course, students will learn about the thermodynamics, physics and chemistry of combustion.

REFERENCES:
COURSE OBJECTIVES:
01. Impart knowledge to the student on the fundamentals and importance of vibration theory
02. Familiarization with the applications of the convolution integral
03. Ability to calculate natural frequencies and mode shapes for simple systems
04. Familiarization with approximate solution techniques in vibration problems
05. Knowledge and ability to derive the governing differential equations of a continuous system

UNIT I  FREE VIBRATION OF A SINGLE DEGREE OF FREEDOM SYSTEM  9

UNIT II  FORCED VIBRATION OF A SINGLE DEGREE OF FREEDOM SYSTEM  9

UNIT III  TWO DEGREE OF FREEDOM SYSTEMS  9

UNIT IV  MULTI DEGREE OF FREEDOM SYSTEMS  9

UNIT V  VIBRATION OF CONTINUOUS SYSTEMS  9

COURSE OUTCOMES:
CO1 Ability of a student to model a given physical system into a single or multi-degree of freedom system.
CO2 Ability to extract natural frequencies of a multi degree of freedom system using approximate methods
CO3 Students are able to model a physical system into a single or multi-degree of freedom system.
CO4 C E A
CO5 Students are able to model a physical system into a single or multi-degree of freedom system.

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COURSE OBJECTIVES:
Of this course are
1. To make students familiarize about Drones
2. Learn about the various components of drone design.
3. To gain knowledge about the Drone subsystems
4. To impart knowledge on Drone propulsion
5. To introduce the basic concepts and types of Drone propulsion

UNIT V DRONE INTRODUCTION
Definition and history of drones, Types of drones, Importance of Drone Rules and Regulation, - Indian Drone Rules History & Evolution, - Indian Drone Rules 2021, - Drone Quality Certification Scheme related to propulsion

UNIT V DRONE DESIGN AND ASSEMBLY
Design considerations for drone airframe and propulsion systems, Selecting and assembling drone components such as motors, batteries, Electronic Speed controllers, Flight controllers, and cameras, Basic wiring and component layout.

UNIT V DRONE MOTOR
Working, Types: Brushed and Brushless Motors, motor sizing and identification, mounting patterns and thread size, Thrust to Weight ratio, KV ratings, advanced motor selection, BLDC Motor -Speed control methods -PWM techniques - Embedded processor based BDLC motor speed control. Life cycle test.

UNIT V PROPULSION SYSTEM
Introduction to Propulsion, - Types of propellers, - Types of Propulsion system, - hybrid fuel-electric, solar, - Types of drone engines, - Two-stroke, - Turbofan, - Turboprop, - Piston engine.

UNIT V TESTING OF DRONE PROPULSION

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Acquire knowledge on the Drones
CO2 Gain Insights on Drone components, design, design standards and System selection
CO3 Acquire knowledge on Drone motor, Battery and ESC
CO4 Gain Insights on Drone propulsion system
CO5 Acquire Knowledge on Drone subsystem testing and Data Interpretation and its challenges.

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AV3023 SPACECRAFT NAVIGATION GUIDANCE AND CONTROL

COURSE OBJECTIVES:
1. To learn about the concepts of Spacecraft Navigation Guidance and Control subsystems and understand their significance
2. To know the operating principle of various sensors and actuators
3. To have an exposure on various Navigation systems such as Inertial Measurement systems and Satellite Navigation
4. To study longitudinal dynamics and to design the longitudinal autopilot
5. To study about the Relative Navigation Systems
6. To understand the Attitude dynamics and Stabilization Control system

UNIT I NAVIGATION CONCEPTS

UNIT II GYRO SYSTEMS
Gyroscopes - Types – Mechanical - Electromechanical-Optical Gyro - Ring Laser gyro - Fiber optic gyro - Rate Gyro, Rate Integrating Gyro, Free Gyro, Vertical Gyro, Directional Gyro, Analysis & Applications

UNIT III INERTIAL NAVIGATION SYSTEMS
Accelerometers – Pendulous type – Force Balance type – MEMs Accelerometers - Basic Principles of Inertial Navigation – Types - Platform and Strap down - Mechanization INS system - Rate Corrections - Block diagram – Acceleration errors – Coriolis effect - Schuler Tuning - Cross coupling - Gimbal lock – Alignment

UNIT IV GPS & HYBRID NAVIGATION SYSTEMS

UNIT V RELATIVE NAVIGATION SYSTEMS
Relative Navigation – fundamentals – Equations of Relative Motion for circular orbits (Clohessy_Wiltshire Equations) - Sensors for Rendezvous Navigation - RF Sensors - Relative Satellite Navigation - Differential GSP - Relative GPS- Optical rendezvous sensors (Laser type and Camera type) - Formation Flying - Figure of Merit (FOM)

COURSE OUTCOMES:
Students will be able to:
CO1 Understand and Apply the concepts of Spacecraft Navigation Guidance and Control subsystems
CO2 Explain the principle of operation various sensors and actuators and their significances
CO3 Explain the principle of operation of Inertial Measurement systems and Satellite Navigation.
CO4 Understand Relative Navigation system and Rendezvous & Docking concepts
CO5 Explain the Attitude dynamics and Stabilization and FBW Control system

TOTAL : 45 PERIODS

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