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

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

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

PEO 1: Successful Moulding of Graduate into Aeronautical Engineering Professional: Graduates of the programme will acquire adequate knowledge both in practical and theoretical domains in the field of Aeronautical Engineering 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 Aircraft industries and the allied management organisations.

PEO 3: Contribution to Aeronautical Engineering Field: Graduates of the programme will have innovative ideas and potential to contribute for the development and current needs of the Aircraft 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 Aeronautical field:** Graduates will have interest and strong desire to undertake research-oriented jobs in industries and doctoral studies in Universities.

**PROGRAMME OUTCOMES (POs)**

After going through the two years of study, Aeronautical Engineering Post-Graduates will exhibit the following.

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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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<td>2.</td>
<td>Conduct investigations of complex problems</td>
<td>Postgraduate will have a firm scientific, technological and communication base that helps him/her to conduct investigations of complex problems in the Aircraft industry and R&amp;D organizations related to Aeronautical engineering and other professional fields.</td>
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<td>3.</td>
<td>The Engineer and society</td>
<td>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.</td>
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<td>4.</td>
<td>Environment and sustainability</td>
<td>Postgraduate will exhibit awareness of contemporary issues on environment focusing on the necessity to develop new materials, design and testing methods for the solution of environmental problems related to Aircraft industry.</td>
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<td>5.</td>
<td>Individual and team work</td>
<td>Postgraduate will exhibit capability towards design and development of airframes from system integration point of view that requires team work.</td>
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<td>6.</td>
<td>Report writing skill</td>
<td>Postgraduate will have the ability to write and present a Comprehensive technical report and research articles.</td>
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**PROGRAMME SPECIFIC OUTCOMES (PSOs)**

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

**PSO 2:** The post graduate will come well versed with usage of modern techniques, and software tools to design and develop Aeronautical 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 Aircraft industries.

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

Mapping of PEOs with Pos

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*Note: The table represents the mapping of course outcomes with programme outcomes. Each row indicates a course and its corresponding programme outcomes (PO) and programme-specific outcomes (PSO) across different semesters.*
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### SEMESTER III

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#### THEORY

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**TOTAL NO. OF CREDITS: 71**

### SEMESTER IV

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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  12

UNIT II  LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS  12
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  12

UNIT I  CALCULUS OF VARIATIONS  12
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  12
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.

REFERENCES:

**CO-PO Mapping:**

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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.

TOTAL: 45 PERIODS

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

REFERENCES:
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
COURSE OBJECTIVES: This course will enable the students
1. To gain knowledge on fundamental principles of aircraft and rocket propulsion.
2. To describe various types of propulsion system with their merits and challenges.
3. To gain adequate knowledge on propellers and its characteristics.
4. To be familiar with the working concept of inlets, nozzles and combustion chamber with their applications in a propulsion system.
5. To gain sufficient information about compressors and turbines. Students also will get an exposure on electric propulsion methods.

UNIT I ELEMENTS OF AIRCRAFT PROPULSION 9
Classification of power plants – Methods of aircraft propulsion – Propulsive efficiency – Specific fuel consumption – Thrust and power- Factors affecting thrust and power- Illustration of working of Gas turbine engine – Characteristics, advantages and disadvantages of turboprop, turbofan and turbojet, Ram jet, Scram jet –flight regimes diagram for different power-plants – Methods of Thrust augmentation.

UNIT II PROPELLER THEORIES 9
Momentum theory, Blade element theory, combined blade element and momentum theory, Propeller co-efficient - propeller power losses, propeller performance parameters, prediction of static thrust- and in flight thrust and power, negative thrust, prop fans, ducted propellers, propeller noise, propeller selection, propeller charts, UAV propellers and applications.

UNIT III INLETS, NOZZLES AND COMBUSTION CHAMBERS 9

UNIT IV AXIAL AND CENTRIFUGAL FLOW COMPRESSORS, FANS AND TURBINES 9

UNIT V ROCKET AND ELECTRIC PROPULSION 9

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, students will

CO1 Get knowledge on different types of propulsive devices and their advantages and disadvantages
CO2 Understand different propeller theories and performance parameters.
CO3 Be able to distinguish between different types of inlets, nozzles and combustion chambers and the process of combustion.
CO4 Know the difference between axial and centrifugal compressors, and the performance and features of turbines.
CO5 Acquire knowledge on the basics of rockets and electric propulsion systems.

REFERENCES:
COURSE OBJECTIVES:
1. Determination of loads acting on aircraft components
2. Knowledge of the theoretical principles of stressed skin construction
3. Knowledge of the generalized theory of beam bending & an understanding of stress distribution in sandwich beams
4. Exposure to the methods of shear flow analysis in aircraft structures
5. Exposure to the behavior of thin plates under different types of loading

UNIT I  AIRCRAFT LOADS  12
Loads Acting on an Aircraft – Balancing Tail Loads – Determination of the Load Factor during Symmetric Manuevers – Inertia Loads – Function of Aircraft Wing & Fuselage Components
Airworthiness Requirements – Construction of the V-n Diagram – Effect of Gust

UNIT II  PRINCIPLES OF STRESSED SKIN CONSTRUCTION  12

UNIT III  ANALYSIS OF BEAMS  12

UNIT IV  SHEAR FLOW ANALYSIS  12
Shear Flow in Thin-Walled Beams – Determination of the Shear Centre Position in Symmetrical and Unsymmetrical Cross-Sections – Structural Idealization – Flexural Shear Flow in Box Beams – Shear flow due to Combined Bending & Torsion – Torsion of Thin-Walled Open Sections Stress
Shear Flow Analysis of Aircraft Components – Thin-Webbed Tapered Beams

UNIT V  THIN PLATES  12
Pure Bending of Thin Plates – Thin Plates Under Combined Loading – Stress Resultants – Buckling of Thin Plates in Compression – Plate Buckling Coefficient – Ultimate Strength of Stiffened Sheets – Effective Sheet Width – Needham Method – Gerard Method – Instability of Thin-Walled Columns – Local Buckling & Crippling – Analysis of Tension Field Beams

TOTAL : 60 PERIODS

COURSE OUTCOMES:
CO1 Ability to calculate load factors and balancing tail loads
CO2 An understanding on the construction and importance of the V-n diagram
CO3 Understand design philosophies and airworthiness requirements
CO4 Ability to carry out shear flow calculations involving aircraft components
CO5 Knowledge of thin plate behavior and ability to design plate elements

REFERENCES:

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COURSE OBJECTIVES:
1. To gain insights into the basics of fluid flow, its model and tool to solve the fluid flow problems.
2. To be familiar with the conservation laws of fluid dynamics, and how to apply them to practical fluid flows.
3. To gain knowledge on elementary flows to combine and form realistic flows with suitable assumptions.
4. To analyse incompressible flow over three-dimensional bodies like wing and so on.
5. To gain knowledge on the basic concepts of viscous flows, boundary layers to practical flows.

UNIT I INTRODUCTION TO AERODYNAMICS
Aerodynamic force and moments, lift and Drag coefficients, Centre of pressure and aerodynamic centre, Coefficient of pressure, moment coefficient, Continuity and Momentum equations, Point source and sink, doublet, Free and Forced Vortex, Uniform parallel flow, combination of basic flows, Pressure and Velocity distributions on bodies with and without circulation in ideal and real fluid flows, Magnus effect

UNIT II INCOMPRESSIBLE FLOW THEORY

UNIT III COMPRESSIBLE FLOW THEORY

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS
Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, transonic area rule, Swept wings (ASW and FSW), Supersonic airfoils, Shock-Expansion Theory, Wave drag, Delta wings.

UNIT V VISCOUS FLOW THEORY

COURSE OUTCOMES:
Upon completion of this course, students will
CO1 Comprehend the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.
CO2 Be able to solve inviscid, incompressible and irrotational flows.
CO3 Be able to apply the conservation equations for fluid flows.
CO4 Be provided with the knowledge on thermodynamic state of the gas behind normal shock waves, oblique shock waves and expansion waves.
CO5 Be provided with adequate knowledge on the basic concepts of laminar and turbulent boundary layers.

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COURSE OBJECTIVES:
This laboratory course will enable the students
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

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COURSE OBJECTIVES:
This course will enable the students
1. To gain knowledge on wall pressure distribution on subsonic and supersonic inlets and nozzles.
2. To perform testing on compressor blades.
3. To interpret the experimental data using software.
4. To get practical exposure on flow visualization techniques pertaining to supersonic jets.
5. To gain basic knowledge on cold flow studies.

LIST OF EXPERIMENTS:
1. Wall pressure measurements of a subsonic diffuser.
2. Cascade testing of compressor blades.
3. Pressure distribution on a cavity model.
4. Wall pressure measurements on non-circular combustor.
5. Wall pressure measurements on converging nozzle.
6. Wall pressure measurements on convergent-divergent nozzle.
7. Total pressure measurements along the jet axis of a circular subsonic jet.
8. Total pressure measurements along the jet axis of a circular supersonic jet.
9. Cold flow studies of a wake region behind flame holders.
10. Wall pressure measurements on supersonic inlets.
11. Flow visualization on supersonic jets.

Only 10 experiments will be conducted.

TOTAL :  60 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be
CO1  Able to perform wall pressure distribution on subsonic and supersonic nozzles.
CO2  Able to acquire knowledge on fundamental concepts of low speed and high speed jets and an experimental technique pertains to measurements.
CO3  Provided with adequate knowledge on pressure distribution on cavity models.
CO4  Able to perform wake survey methods.
CO5  Able to carry out flow visualization on supersonic jets.

LABORATORY EQUIPMENTS REQUIRED
1. Subsonic wind tunnel
2. High speed jet facility
3. Blower
4. Pressure scanner
5. Schlieren system
6. Nozzle and cavity models
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COURSE OBJECTIVES: of this course are
1. To gain strong knowledge on aircraft performance in level, climbing, gliding flights.
2. To get familiarize with the equations pertaining to coordinated turn and in accelerated flight modes.
3. To provide adequate knowledge on various parameters that decide the pitch stability level of an airplane.
4. To impart knowledge on the basic aspects of lateral and directional stability and trim.
5. To be familiar with the equations of motion associated with longitudinal, lateral-directional dynamics.

UNIT I STEADY FLIGHT PERFORMANCE 9+3

UNIT II MANEUVER PERFORMANCE 9+3
Steady Coordinated Turn - maximum producible load factor - Limitations on load factor - fastest and tightest turn - Vertical maneuver: pull-up and pull-down - effect of gust on V-n diagram - Take off and landing performance.

UNIT III STATIC LONGITUDINAL STABILITY AND CONTROL 9+3
Fundamentals of Static Equilibrium and Stability - Simplified Pitch Stability Analysis for a Wing-Tail Combination - Estimating the Downwash Angle on an aft Tail - Stick-Fixed Neutral Point and Static Margin. Simplified Pitch Stability Analysis for a Wing-Canard and flying wing configuration - Stick free stability - Hinge moment, Free elevator factor, Power effects - propeller and jet aircrafts, longitudinal control, elevator effectiveness, elevator control power, elevator angle to trim, most forward C.G, elevator angle per 'g', maneuver point, control force gradient and control force per 'g'. Flight measurement of neutral and maneuver points - Aerodynamic balancing of control surfaces.

UNIT IV STATIC LATERAL, DIRECTIONAL STABILITY AND TRIM 9+3
Yaw stability and trim - contribution by wing, fuselage, tail - Estimating the Sidewash Gradient on a Vertical Tail - Rudder fixed and rudder free aspects, pedal force - Rudder lock and Dorsal fin, Directional control, rudder requirements. Lateral stability - Dihedral effect, criteria for lateral stability, evaluation of lateral stability - contribution of fuselage, wing, fuselage, tail, total static lateral stability, roll control, strip theory estimation of aileron control power, roll control by spoilers, aileron reversal, aileron reversal speed.

UNIT V AIRCRAFT DYNAMICS 9+3

TOTAL: 60 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Assess the performance of aircraft in steady and level flight and draw the hodographs for
steady climb, powerless glide.

CO2 Compute the accelerated performance of an aircraft and also construct the V-n diagram with gust loads.

CO3 Perform preliminary design computations to meet static stability and trim requirements of conventional and unconventional aircraft configurations.

CO4 Evaluate dihedral effect of a given airplane and design the rudder by considering certain critical situations.

CO5 Analyse the longitudinal, lateral-directional modes of motion of an airplane and evaluate the associated stability and control derivatives.

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COURSE OBJECTIVES: The objectives of the course are

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

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


UNIT III  TIME DEPENDENT METHODS AND THEIR APPLICATIONS

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

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

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.
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 can be conducted.  TOTAL : 45Periods+30Periods

COURSE OUTCOMES: Upon completion of the course students will be able

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:
01. Basic understanding of different methods of analysis for the solution of static structural problems
02. Knowledge of how finite element equations are formulated
03. An understanding of how characteristic matrices are generated
04. Exposure to different finite elements and awareness of element capability
05. 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  

EXPERIMENTS IN FEM  
LIST OF EXPERIMENTS:  
1. Static analysis of a uniform bar subject to different loads -1-D element  
2. Thermal stresses in a uniform and tapered member – 1-D element  
3. Static analysis of trusses / frames under different loads  
4. Stress analysis & deformation of a beam using 1-D element & 2-D – incorporation of discrete, distributed, and user-defined loads  
5. Stress concentration in an infinite plate with a small hole  
6. Free vibration analysis of a bar / beam

TOTAL : 45 Periods+30 Periods

COURSE OUTCOMES:
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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AL3211 AIRCRAFT STRUCTURES LABORATORY L T P C
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. Experiments in Symmetrical Bending of Beams
2. Unsymmetrical Bending of Beams
3. Installation and Performance of Electrical Resistance Strain Gauges
4. Strain Measurement Using Electrical Resistance Strain Gauges – Combined Loading
5. Shear Center Position of Thin-Walled Beams
6. Transmission and Reflection Polariscope Experimental Set-up & Working Principle
7. Calibration of a Photoelastic Specimen
8. Fabrication of a Composite Laminates Using Hand Lay-Up/Vacuum Bagging
9. Mechanical Testing and Experimental Characterization Studies
10. Non-Destructive Evaluation of Composites – Ultrasonics / Acoustic Emission
11. Fatigue Testing of 3-D Printed Specimens
12. Behaviour & Buckling Load of Practical Columns
13. Failure and Strength of Thin –Walled Columns
14. Experimental Modal Analysis
15. Forced Vibration and Resonance Testing of Aircraft & Aerospace Components

Any 10 experiments will be conducted from above 15 experiments

TOTAL : 60 PERIODS

COURSE OUTCOMES:
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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DIRECTOR
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 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 9

UNIT II SATELLITE DYNAMICS 9

UNIT III ROCKET MOTION 9
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 9

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES 9
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

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COURSE OBJECTIVES:
1. To introduce the basic of avionics systems and its need for civil and military aircrafts.
2. To impart knowledge on different avionic architecture and various avionics data buses.
3. To impart knowledge on different cockpit displays and display technologies.
4. To impart knowledge on different navigation systems and their operating principles.
5. To impart knowledge on the functions of FMS and Iilities of avionics.

UNIT I  INTRODUCTION TO AVIONICS
Need for avionics in civil and military aircraft and space systems – System Integration - Integrated avionics and weapon systems – Typical avionics subsystems, Air data quantities – Altitude, Air speed, Vertical speed, Mach number - design, technologies – Introduction to Digital Computer and memories.

UNIT II  DIGITAL AVIONICS ARCHITECTURE

UNIT III  FLIGHT DECKS AND COCKPITS
Control and display technologies: CRT, LED, LCD, EL and plasma panel – Touch screen – Direct voice input (DVI) – Civil and Military Cockpits: MFDS, HUD, MFK, HOTAS.

UNIT IV  INTRODUCTION TO NAVIGATION SYSTEMS

UNIT V  AUTO PILOT AND FMS
Functions of FMS – Auto pilot – FADEC - Basic principles, Longitudinal and lateral auto pilot - Iilities of Avionics, Reliability, Availability, and Maintainability – BITE.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, Students will be able to
CO1 Explain the need for avionics in aircrafts and explain the functions of basic aircraft systems.
CO2 Select a suitable avionics architecture based on requirements and explain the functions of a data bus.
CO3 Explain the working of cockpit displays and to distinguish the type of technology used in displays.
CO4 Explain the importance of navigation system and operating principles of different navigation systems.
CO5 Explain the functions of autopilot and compare the different types of air speeds.

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COURSE OBJECTIVES:

1. To get insights into the basic aspects of material science and mechanical behavior of materials.
2. To provide basic idea on ferrous and non-ferrous materials.
3. To gain knowledge on the analysis and manufacturing methods of composite materials.
4. To gain knowledge on smart materials.
5. To provide basic idea on high temperature characterization.

UNIT I  MATERIAL SCIENCE and MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS


UNIT II  FERROUS AND NON-FERROUS MATERIALS


UNIT III  CERAMICS AND COMPOSITES

Introduction, modern ceramic materials, cermets, glass ceramic, production of semi-fabricated forms, Carbon/Carbon composites, Fabrication processes and its aerospace applications involved in metal matrix composites, polymer composites.

UNIT IV  SMART MATERIALS


UNIT V  HIGH TEMPERATURE MATERIALS

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, High temperature material characterization.

COURSE OUTCOMES:

Upon completion of this course, Students will be able to

CO1 provide with the knowledge and skills required to carry out the selection of appropriate materials for a wide range of engineering and other applications and apply the knowledge about the mechanical behaviour of different aircraft & aerospace materials.

CO2 Understand and evaluate the properties of ferrous and non-ferrous materials in aerospace industry

CO3 Explain the applications of Aluminum alloys, Ceramics and Composites Materials.

CO4 Understand and apply the smart materials in aerospace industry

CO5 evaluate the importance of high temperature materials and their characterization.
REFERENCES:
5. Brian Culshaw, Smart Structures and Materials, Artech House, 2000

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COURSE OBJECTIVES:
This course will make students
1. Understand the principles and components of piston engines.
2. Analyze propeller systems and perform inspections and repairs.
3. Develop skills for engine inspection, testing, and repair procedures.
4. Gain knowledge of jet engine types, maintenance, and troubleshooting.
5. Acquire skills for jet engine overhaul and component balancing.

UNIT I  BASIC OF PISTON ENGINE INSPECTION AND MAINTENANCE  9
Classification of piston engines - Principles of operation - Function of components – Materials used- Details of starting the engines - carburetion and Fuel injection systems for small and large engines - Ignition system components - spark plug detail - Engine operating conditions at various altitudes–Engine power measurements–Classification of engine lubricants and fuels-Induction, Exhaust and cooling system - Maintenance and inspection check to be carried out. Routine maintenance and inspection procedures for piston engines Pre-flight inspections, oil changes, filter replacements, etc. Troubleshooting - Inspection of all engine components – Daily and routine checks-Overhaul procedures Overview of engine overhaul process- Major maintenance tasks, component replacements, and inspection during overhaul

UNIT II  PROPELLER INSPECTION AND REPAIR  9
Basic principles and concepts of propeller operation- Propeller terminology and characteristics - Operation, construction assembly and installation -Pitch change mechanism- Propeller axially system- Damage and repair criteria - General Inspection procedures - Checks on constant speed propellers - Pitch setting, Propeller Balancing, Blade cuffs, Governor/Propeller operating conditions – Damage and repair criteria- Guidelines for determining the permissible limits of propeller damage- Repair procedures for various types of propeller damage

UNIT III  ENGINE INSPECTION, TESTING AND REPAIR  9

UNIT IV  JET ENGINE INSPECTION AND MAINTENANCE  9
Types of jet engines – Fundamental principles – Bearings and seals - Inlets - compressors -turbines-exhaust section – classification and types of lubrication and fuels- Materials used –Details of control, starting around running and operating procedures -Inspection and Maintenance-permissible limits of damage and repair criteria of engine components- internal inspection of engines- compressor washing- field balancing of compressor fans- Component maintenance procedures - Systems maintenance procedures - use of instruments for online maintenance-Techniques and procedures for conducting maintenance tasks while the engine is operational-Special inspection procedures-Foreign Object Damage-Blade damage.

UNIT V  JET ENGINE OVERHAUL AND TROUBLESHOOTING  9
Engine Overhaul - Overhaul procedures - Inspections and cleaning of components – Repairs schedules for overhaul - Balancing of Gas turbine components. Trouble Shooting: Procedures for trouble shooting - Condition monitoring of the engine on ground and at altitude – engine health monitoring and corrective methods- Incorporating updates and modifications during engine overhaul- Safety Considerations in Overhaul- Maintenance record management and traceability
COURSE OUTCOMES: Upon completion of this course, the students should be able to
CO1 Understand piston engine principles and identify engine components.
CO2 Perform propeller inspections, repairs, and checks according to criteria.
CO3 Apply engine testing and diagnostic techniques for maintenance and troubleshooting.
CO4 Demonstrate proficiency in jet engine inspection, maintenance, and overhauling.
CO5 Analyze engine performance data and implement appropriate repair procedures.

REFERENCES:
2. UnitedTechnologies’Pratt&Whitney,"TheAircraftGasturbineEngineanditsOperation",The English
Book Store, NewDelhi.
Sanderson, 2004

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COURSE OBJECTIVES: of this course are
1. This course will enable the students to learn basics of wind tunnel operation and its associated measurements.
2. To present the concepts of different flow visualization methods.
3. This course also imparts knowledge on flow measurement variables
4. This course enables students to be familiar with data acquisition methods pertaining to experiments in aerodynamics.
5. This course will help students to do uncertainty analysis for their experiments.

UNIT I  LOW SPEED TUNNEL

UNIT II  HIGH SPEED TUNNEL

UNIT III  FLOW VISUALIZATION TECHNIQUES

UNIT IV  MEASUREMENTS OF PROPERTIES

UNIT V  DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Have knowledge on measurement of flow properties in wind tunnels and their associated instrumentation.
CO2 Be able to demonstrate and conduct experiments related to subsonic and supersonic flows.
CO3 Gain idea on flow visualization of subsonic and supersonic flows.
CO4 Be familiar with calibration of transducers and other devices used for flow measurement.
CO5 Be able to estimate errors and to perform uncertainty analysis of the experimental data.

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Centre for Academic Courses
Anna University, Chennai-600 025
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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
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 coordinate, Governing equations convective- Force and free convection and radiative heat transfer.

UNIT III FINITE DIFFERENCE FORMULATION FOR CONDUCTIVE HEAT TRANSFER

UNIT IV FINITE DIFFERENCE FORMULATION FOR CONVECTIVE AND 10 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.

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

TOTAL: 45 PERIODS

COURSE OUTCOMES:
 Upon completion of this course, Students will

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. To provide the basic knowledge on the properties of fiber and matrix materials used in commercial composites as well as some common manufacturing techniques.
2. To determine stresses and strains in composites and also imparts an idea about the manufacturing methods of composite materials
3. To impart knowledge on the macro mechanics of composite materials.
4. To get the knowledge in failure modes of composites.
5. To get an idea on failure theories of composites.

UNIT I  INTRODUCTION TO COMPOSITE MATERIALS

UNIT II  MICROMECHANICS OF COMPOSITES

UNIT III  MACROMECHANICS OF COMPOSITES

UNIT IV  MONOTONIC STRENGTH AND FRACTURE
Tensile and Compressive strength of Unidirectional Fiber Composites - Fracture Modes in Composites - Single and Multiple Fracture – Debonding - Fiber Pullout and Delamination Fracture - Strength of an Orthotropic Lamina - Maximum Stress Theory - Maximum Strain Criterion - Tsai-Hill Criterion - Ts - Wu tensor theory- Comparison of Failure Theories.

UNIT V  FAILURE ANALYSIS AND DESIGN OF LAMINATES

TOTAL : 45 PERIODS

COURSE OUTCOMES:
CO1  To identify the properties of fiber and matrix materials used in commercial composites.
CO2  To select the most appropriate manufacturing process for fabricating composite components.
CO3  To predict the failure strength of a laminated composite plate
CO4  Understand the linear elasticity with emphasis on the difference between isotropic and anisotropic material behaviour.
CO5  Acquire the knowledge for the analysis, design, optimization and test simulation of advanced composite structures and Components.
REFERENCES:
3. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993

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COURSE OBJECTIVES: of this course are
1. To introduce the basic concepts of aerodynamics.
2. To impart knowledge about steady flight performance of conventional aircraft.
3. To provide basic knowledge on static stability and trim requirements of aircraft.
4. To impart knowledge on different types of engines used on aircraft and modern materials.
5. To provide basic knowledge on rocket types and trajectories.

UNIT I ESSENTIALS OF AERODYNAMICS

UNIT II FLIGHT PERFORMANCE
Steady and level flight - Thrust and Power required curves - Cruise velocity expression - Stall velocity - Steady climb - ROC and Climb angle - Powerless glide - ROD and Glide angle - Range and Endurance of jet and propeller-driven aircraft.

UNIT III INTRODUCTION TO STABILITY AND CONTROL
Principles of stability and control - Longitudinal stability - Criteria and contribution - Trim requirements - Elevator control power - Weathercock stability - Contribution from components - Rudder requirements - Dihedral effect - contribution of various components - aileron control.

UNIT IV AIRCRAFT PROPULSION AND MATERIALS
Thrust equation - Working of Gas Turbine Engines - relative advantages and disadvantages. Introduction to Aircraft structures - load carrying members on Wing and Fuselage - Different types of construction - Materials used on modern airplane and their requirements.

UNIT V FUNDAMENTALS OF ROCKET MOTION

TOTAL : 45 PERIODS

COURSE OUTCOMES:
Upon completion of the course, Students will be able to
CO1 Determine the properties of atmosphere at a given altitude in ISA and categorize flight vehicle configurations.
CO2 Evaluate the cruise, climbing and gliding capabilities of a given aircraft.
CO3 Ensure longitudinal, directional and lateral stability and trim of a flight vehicle design.
CO4 Select an efficient engine as per the design requirement and identify different structural components of an airplane.
CO5 Calculate the velocity increment of single and multi-stage rockets with given rocket parameters.

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</table>
UNIT I  ATMOSPHERE  9
Types of winds, Causes of variation of winds, Atmospheric boundary layer, Effect of terrain on
gradient height, Structure of turbulent flows.

UNIT II  WIND ENERGY COLLECTORS  9
Horizontal axis and vertical axis machines, Power coefficient, Betz coefficient by momentum theory.

UNIT III  VEHICLE AERODYNAMICS  9
Power requirements and drag coefficients of automobiles, Effects of cut back angle, Aerodynamics
of trains and Hovercraft.

UNIT IV  BUILDING AERODYNAMICS  9
Pressure distribution on low rise buildings, wind forces on buildings. Environmental winds in city
blocks, Special problems of tall buildings, Building codes, Building ventilation and architectural
aerodynamics.

UNIT V  FLOW INDUCED VIBRATIONS  9
Effects of Reynolds number on wake formation of bluff shapes, Vortex induced vibrations, Galloping
and stall flutter.

COURSE OUTCOMES:
Upon completion of the course, students will learn about non-aeronautical uses of aerodynamics
such as road vehicle, building aerodynamics and problems of flow induced vibrations.

REFERENCES:
COURSE OBJECTIVES:
1. To learn the basic concepts and equations of elasticity.
2. To provide with the concepts of plain stress and strain related problems.
3. To gain knowledge on equilibrium and stress-strain equations of polar coordinates.
4. Will be exposed to axisymmetric problems.
5. To get insight into the basic concepts of plates and shells.

UNIT I INTRODUCTION

UNIT II CONCEPT OF STRESSES AND STRAINS

UNIT III POLAR COORDINATES
Strain components in polar coordinates – Equilibrium and stress-strain equations in polar coordinates – Effect of circular holes in plates – Stress concentration – Bending of a curved beam (Winkler-Bach theory) – Deflection of a thick curved bar – rotating discs, walled cylinders, infinite plate with point load.

UNIT IV AXISYMMETRIC PROBLEMS
Equilibrium and stress-strain equations in cylindrical coordinates – Lame’s problem – Thick walled cylinders subject to internal and external pressure – Application of failure theories – Stresses in composite tubes – Shrink fitting – Stresses in rotating discs Stress due to gravitation — Rotating shafts and cylinders – Application of Thick cylinders.

UNIT V INTRODUCTION TO PLASTICITY & YIELD CRITERIA
Overview of plasticity and its importance in engineering-Brief history and development of plasticity theory-Basic concepts: stress, strain, deformation, and yield criteria-Review of stress and strain tensors-Equilibrium equations and compatibility conditions-Constitutive equations: linear elasticity and plasticity-Overview of yield criteria and their significance Tresca yield criterion-Von Mises yield criterion-Other yield criteria: Mohr-Coulomb, Drucker-Prager, etc.

TOTAL : 45 PERIODS

COURSE OUTCOMES:
CO1 Have knowledge of basic elasticity relationships and equations.
CO2 Know how to carry out stress analysis in 2-D and 3-D.
CO3 Get exposure on the formulation of constitutive and governing equations for basic problems in cartesian and cylindrical coordinates.
CO4 Be able to analyse and solve practical problems in cartesian and cylindrical coordinates.
CO5 Be able to determine the stress, strain and displacement field for common axisymmetrical members.

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COURSE OBJECTIVES: This course will make students
1. This course will make students to provide with introductory concepts of types of rotorcrafts.
2. This course imparts knowledge on the fundamental aspects of helicopter aerodynamics and performance of helicopters.
3. This course will provide basic knowledge on the performance of helicopters.
4. This course presents stability and control aspects of helicopters.
5. This course will explore the basic aerodynamic design aspects of helicopters.

UNIT I HELICOPTER AERODYNAMICS
Types of rotorcrafts – auto gyro, gyrodyne, helicopter, Configuration Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti-torque pedals. Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, induced velocity, local solidity, performance of ideally twisted constant chord blade, rapid performance in hover.

UNIT II PERFORMANCE IN HOVER AND CLimb
Optimum hover rotor, induced torque, profile drag torque, performance equation, optimum rotor design, ground effect, Flow stated of rotor-Normal working state, vortex-ring state, windmill state, vertical descent performance, autorotation diagram.

UNIT III PERFORMANCE IN HORIZONTAL FLIGHT
Flapping and lag hinge, steady hover, equilibrium in horizontal blade, blade hinge motion, induced velocity, blade element angle of attack, flapping coefficient, Forward flight-performance equation, drag-lift ratio, parasite drag coefficient, climb drag lift ratio, blade stall.

UNIT IV STABILITY AND CONTROL
Helicopter Trim, Static stability – Incidence disturbance, forward speed disturbance, angular velocity disturbance, yawing disturbance, Dynamic Stability.

UNIT V AERODYNAMIC DESIGN
Blade section design, Blade tip shapes, Drag estimation – Rear fuselage upsweep, vibration problem of Helicopter blades.

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, students will be able to
CO1 Describe and compare possible helicopter structures and configurations.
CO2 Identify features of aerodynamic components of rotary wing aircraft and its performance.
CO3 Describe the aerodynamic characteristics that affect rotary wing flight.
CO4 Idea about the factors that influence helicopter stability.
CO5 Gain knowledge of helicopter controls and vibration analysis of helicopter blades.

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COURSE OBJECTIVES: of this course are
1. To impart knowledge on the different phases involved in the design and development of avionic systems.
2. To familiarize with aviation standards related to design & development of hardware & software.
3. To impart knowledge on the need for certification and the airworthiness certification process.
4. To impart knowledge on the need for reliability, maintainability and different methods of expressing reliability.
5. 

UNIT I AVIONICS SYSTEM ENGINEERING DEVELOPMENT CYCLE

UNIT II AVIATION STANDARDS

UNIT III AIRWORTHINESS CERTIFICATION

UNIT IV RELIABILITY & MAINTAINABILITY CONCEPTS IN AVIONICS SYSTEMS

UNIT V QUALITY ASSURANCE PROCESS IN AVIATION

TOTAL : 45 PERIODS
COURSE OUTCOMES:
Upon completion of the course, Students will be able to

CO1  Explain the different steps involved in the design and development of Avionic systems.

CO2  Apply the aviation standards during the design and development of hardware and software

CO3  Explain the importance of airworthiness certification and differentiate between different certification process

CO4  Explain the importance of system reliability and compare the different methods of expressing reliability and types of maintenance

CO5  Compare and select suitable quality assurance process and management tool for quality assurance.

REFERENCES:
7. SAE ARP4754, Certification Considerations for Highly-Integrated or Complex Aircraft Systems, SAE, Warrendale, PA, 1996.
9. DDPMAS -2020 (Vol 1 & 2)
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
Staichiometry – 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

UNIT III PREMIXED AND DIFFUSED FLAMES
One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame, Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion.

UNIT IV COMBUSTION IN GAS TURBINE, RAMJET AND SCRAMJET
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

TOTAL : 45 PERIODS

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

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PSO 1: Knowledge and understanding of combustion.
PSO 2: Ability to apply principles of combustion in practical scenarios.
PSO 3: Critical thinking and problem-solving skills.
PSO 4: Communication and presentation skills.

![Director's Signature]
[Anna University, Chennai-600 025]

[CPA Center for Academic Programs]
COURSE OBJECTIVES:
1. This course will cover the basic aspects of thermodynamic cycle analysis of air-breathing propulsion systems.
2. This course is intended to impart knowledge on advanced air breathing propulsion systems like air augmented rockets.
3. This course will give the knowledge on the basic aspects of scramjet propulsion system.
4. This course will provide in-depth knowledge about the nozzle performance.
5. This course also presents vast knowledge on the operating principles of nuclear, electric and ion propulsion.

UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS
Air breathing propulsion systems like Turbojet, turboprop, ducted fan, Ramjet and Air augmented rockets – Thermodynamic cycles – Pulse propulsion – Combustion process in pulse jet engines – inlet charging process – Subcritical, Critical and Supercritical charging – Airbreatning Engine Performance Measures – Aerospace System Performance Measures

UNIT II RAMJETS AND AIR AUGMENTED ROCKETS
Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets – combustor and nozzle design – Integral Ram rocket.

UNIT III SCRAMJET PROPULSION SYSTEM

UNIT IV NUCLEAR PROPULSION

UNIT V ELECTRIC AND ION PROPULSION

COURSE OUTCOMES:
At the end of this course, students will be
CO1: Able to Analyse in detail the thermodynamics cycles of air breathing propulsion systems.
CO2: Able to gain idea on the concepts of supersonic combustion for hypersonic vehicles and its performance.
CO3: Able to demonstrate the fundamental requirements of supersonic combustors.
CO4: Capable of estimating performance parameters of nuclear and electrical rockets
CO5: Able to acquire knowledge on the concepts of engine-body installation on hypersonic vehicles.

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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  9

UNIT II  CLASSICAL LAMINATION THEORY  9

UNIT III  ANALYSIS OF LAMINATED BEAMS AND PLATES  9

UNIT IV  DESIGN OF COMPOSITE STRUCTURES  9
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  9

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
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COURSE OBJECTIVES:
1. Understand welding principles and techniques for aircraft structural components.
2. Develop proficiency in repairing and maintaining plastic and composite materials.
3. Gain knowledge and skills in aircraft jacking, assembly, and rigging procedures.
4. Familiarize with hydraulic and pneumatic systems in aircraft and their maintenance.
5. Learn and apply safety practices for aircraft maintenance and operations.

UNIT I WELDING IN AIRCRAFT STRUCTURAL COMPONENTS
Equipments used in welding shop and their maintenance - Ensuring quality welds – Welding jigs and fixtures - Soldering and brazing. Sheet Metal Repair and Maintenance: Selection of materials; Fabrication of replacement patches; Tools-power/hand; Repair techniques; Close tolerance fasteners; Sealing compounds; forming/shaping; Calculation of weight of completed repair; Effect of weight - change on surrounding structure. Sheet metal inspection - N.D.T. Testing. Design considerations for riveted repairs in aircraft structures - Damage investigation - Reverse engineering.

UNIT II PLASTICS AND COMPOSITES IN AIRCRAFT
Plastics in Aircraft: Review of types of plastics used in airplanes - Maintenance and repair of plastic components - Repair of cracks, holes etc., and various repairs schemes - Scopes. Advanced Composites in Aircraft: Tools and Equipment for Composite Repairs Cleaning of fibre reinforced plastic (FRP) materials prior to repair; Break test - Repair Schemes; FRP/honeycomb sandwich materials; laminated FRP structural members and skin panels; Tools/equipment; Vacuum-bag process.

UNIT III AIRCRAFT JACKING, ASSEMBLY AND RIGGING

UNIT IV REVIEW OF HYDRAULIC AND PNEUMATIC SYSTEM
Troubleshooting and maintenance practices - Service and inspection - Inspection and maintenance of landing gear systems. Inspection and maintenance of air-conditioning and pressurization system, water and waste system. Installation and maintenance of Instruments - handling - Testing - Inspection. Inspection and maintenance of auxiliary systems - Fireprotection systems - Ice protection system - Functionality checks and servicing of position and warning systems - Auxiliary Power Units (APUs).

UNIT V SAFETY PRACTICES
Hazardous materials storage and handling, Aircraft furnishing practices - shooting. Theory and practices. Overview of essential safety equipment used in aviation - Types and functions of personal protective equipment (PPE) - Emergency Response and Preparednes

TOTAL: 45 PERIODS

COURSE OUTCOMES:
Upon completion of this course, the students should be able to
CO1 Apply welding principles to inspect, repair, and maintain aircraft structural components.
CO2 Perform effective repairs on plastic and composite materials used in aircraft.
CO3 Demonstrate proficiency in aircraft jacking, assembly, and rigging techniques.
CO4 Inspect, troubleshoot, and maintain hydraulic and pneumatic systems in aircraft.
CO5 Implement safety practices and procedures in aircraft maintenance operations.
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COURSE OBJECTIVES:
This course will make students to
1. Define and apply key concepts and principles of systems engineering.
2. Analyze and evaluate aircraft systems and their design considerations.
3. Understand the process of systems integration and architecture development.
4. Demonstrate effective communication and stakeholder management skills in systems engineering.
5. Apply reliability and maintainability principles to ensure system performance.

UNIT I INTRODUCTION TO SYSTEMS ENGINEERING

UNIT II THE AIRCRAFT SYSTEMS AND DESIGN
Introduction- Everyday Examples of Systems- Aircraft Systems –Generic Systems-Product Life Cycle- Different Phases-Whole Life Cycle Tasks- Systems Analysis-Techniques and methodologies for analyzing aircraft systems - Identifying system requirements, constraints, and performance objectives-Design Drivers in the Project, Product, Operating Environment- Interfaces with the Subsystems-Missionanalysis

UNIT III SYSTEM ARCHITECTURES AND INTEGRATION

UNIT IV PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL

UNIT V SYSTEMS RELIABILITY AND MAINTAINABILITY

COURSE OUTCOMES:
Upon completion of this course, Students will be able to
CO1 Understand and apply systems engineering principles in practical scenarios.
CO2 Evaluate and analyze aircraft systems and their design drivers.
CO3 Develop effective system architectures and integration strategies in aviation.
CO4 Communicate and manage stakeholders effectively in systems engineering projects.
CO5 Enhance system reliability and maintainability through appropriate strategies and practices.

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COURSE OBJECTIVES:
1. To learn the concept of measurement, error estimation and classification of aircraft instrumentation and displays.
2. To study air data instruments and synchronous data transmission systems.
3. To study gyroscopes and their purposes, aircraft compass system and flight management system.
4. To study data compass and flight management systems.
5. To impart knowledge about the basic and advanced flight instruments, their construction, and its operation.

UNIT I MEASUREMENT SCIENCE AND DISPLAYS

UNIT II AIR DATA INSTRUMENTS AND SYNCHRO TRANSMISSION SYSTEMS
Earth’s Atmosphere – Basic Air data system – Air Data instruments–airspeed, altitude, Vertical speed indicators - Probes – Position Error - Altitude alerting systems, Mach meter, Mach Warning system, Static Air temperature, Angle of attack measurement, Stall Warning system, Stick Shaker - Synchronous data transmission system – Synchros systems – Resolver synchros – Synchrotel

UNIT III GYROSCOPIC AND ADVANCED FLIGHT INSTRUMENTS
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, acceleration and turning errors; Standby Attitude Director Indicator, Gyro stabilized Direction Indicating Systems, Advanced Direction Indicators, Horizontal Situation Indicator.

UNIT IV AIRCRAFT COMPASS SYSTEMS & FLIGHT MANAGEMENT SYSTEM
Aircraft magnetism - Direct reading compass, magnetic heading reference system-detector element, monitored gyroscope system, DGU, RMI, deviation compensator, FMS- Flight planning-flight path optimization-operational modes-4D flight management

UNIT V POWER PLANT INSTRUMENTS & FLIGHT DATA RECORDING
Pressure measurement, temperature measurement, fuel quantity measurement, engine power and control instruments-measurement of RPM, manifold pressure, torque, exhaust gas temperature, EPR, Engine Fuel Indicators, engine vibration monitoring, Cockpit Voice Recorder and Flight Data Recorder.

TOTAL :45 PERIODS

COURSE OUTCOMES:
Students will be able to:
CO1 Understand and apply the concept of measurement, classification of aircraft instrumentation, displays and layouts standards
CO2 Explain about the various air data systems and synchronous data transmissions systems
CO3 Apply the principle of gyroscope to various Advanced Aircraft Instruments
CO4 Classify the aircraft magnetism, understand the Compass systems and FMS in 4D flight management in the Avionics domain requirements
CO5 Explain the operation and importance of Power plant & engine instruments and flight data recorder.

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COURSE OBJECTIVES:
Of this course are
1. Be able to understand the various experimental techniques involved for measuring displacements, stresses, strains in structural components.
2. To familiarize with the different types of strain gages used.
3. To familiarize with the instrumentation system used for strain gauges.
4. Be able to use photoelasticity techniques and methods for stress analysis.
5. Be able to familiarize with the different NDT techniques.

UNIT I  BASICS OF MECHANICAL MEASUREMENTS  9
Basic Characteristics and Requirements of a Measuring System – Principles of Measurements–
Precision, Accuracy, Sensitivity and Range of Measurements – Sources of Error – Statistical Analysis
of Experimental Data – Contact Type Mechanical Extensometers – Advantages and Disadvantages –
Examples of Non-Contact Measurement Techniques.

UNIT II  ELECTRICAL-RESISTANCE STRAIN GAUGES  9
Strain Sensitivity in Metallic Alloys – Gage Construction – Gage Sensitivities and Gage Factor-
Corrections for Transverse Strain Effects – Performance Characteristics of Foil Strain Gages-
Materials Used for Strain Gauges – Environmental Effects – The Three-Element Rectangular Rosette
for Strain Measurement – Other Types of Strain Gages – Semiconductor Strain Gages-Grid & Brittle
Coating Methods of Strain Analysis.

UNIT III  STRAIN-GAUGE CIRCUITS & INSTRUMENTATION  9
The Potentiometer Circuit and Its Application to Strain Measurement – Variations From Basic Circuit
– Circuit Output – The Wheatstone Bridge Circuit – Current and Constant Voltage Circuits – Analog to
Digital Conversion – Calibrating Strain-Gage Circuits – Effects of Lead Wires and Switches –
Electrical Noise — Strain Measurement in Bars, Beams and Shafts – Circuit Sensitivity & Circuit
Efficiency.

UNIT IV  PHOTOELASTIC METHODS OF STRESS ANALYSIS  9
Introduction to Photoelastic Methods – Stress Optic Law – Effects of a Stressed Model in a Plane
Polariscope – Effects of a Stressed Model in a Circular Polariscope - Tardy Compensation - Two-
Dimensional Photoelastic Stress Analysis – Fringe Multiplication and Fringe Sharpening - Materials
for Two-Dimensional Photoelasticity - Properties and Calibration of Commonly Employed Photoelastic
Materials – Introduction to Three-Dimensional Photoelasticity.

UNIT V  NON-DESTRUCTIVE TESTING  9
Different types of NDT Techniques - Acoustic Emission Technique – Ultrasonics – Pulse-Echo–
Through Transmission – Eddy Current Testing – Magnetic Particle Inspection – X-Ray
Radiography – Challenges in Non-Destructive Evaluation – Non-Destructive Evaluation in
Composites – Image Processing Basics.

COURSE OUTCOMES:
Upon completion of this course, Students will be able to
CO1 Analyse the performance of measuring instrumentation.
CO2 Impart knowledge on different methods of strain measurement.
CO3 Design different strain gauge circuits.
CO4 Use photoelasticity for stress analysis.
CO5 Exposure the different types of non-destructive testing methods.
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COURSE OBJECTIVES:
1. To impart knowledge on the fundamentals of nondestructive testing methods and techniques, aircraft inspection methodology using NDT methods.
2. To get insights into the basic aspects of electron microscopy.
3. To learn modern NDT techniques like acoustic emission, ultrasonic and thermographic testing methods.
4. To inspect the aircraft structures using NDT techniques.
5. To get basic knowledge on the structural health monitoring of aerospace structures.

UNIT I
INTRODUCTION

UNIT II
ELECTRON MICROSCOPY
Fundamentals of optics – Optical microscope and its instrumental details – Variants in the optical microscopes and image formation – Polarization light effect – Sample preparation and applications of optical microscopes – Introduction to Scanning electron microscopy (SEM) – Instrumental details and image formation of SEM – Introduction to transmission electron microscopy (TEM) – Imaging techniques and spectroscopy – Sample preparation for SEM and TEM.

UNIT III
ACOUSTIC EMISSION AND ULTRASONICS

UNIT IV
AIRCRAFT INSPECTION

UNIT V
STRUCTURAL HEALTH MONITORING

TOTAL : 45 PERIODS

COURSE OUTCOMES:
CO1 To realize the importance of various NDT techniques.
CO2 To identify suitable NDT technique for a particular application.
CO3 To demonstrate the physical principles involved in acoustic emission and ultrasonics.
CO4 To have knowledge on the physical principles involved in the various other techniques of NDT.
CO5 To realise the state-of-the-art in NDT testing and structural health monitoring.
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COURSE OBJECTIVES:
1. Teach the student different energy principles & its various applications
2. Knowledge of stress-strain equations in 2-D and 3-D
3. Allow the student to differentiate and understand different failures theories
4. Understand how riveted and bolted joints should be designed
5. Gain knowledge on the stress analysis techniques of different structural components

UNIT I ENERGY METHOD OF ANALYSIS

UNIT II ELASTICITY

UNIT III THEORIES OF FAILURE
- Significance of Failure Theories – Principal Stresses in 2-D & 3-D – Maximum Normal Stress, Normal Strain and Maximum Shear Stress Failure Theories – Failure Envelope – Distortion Energy Failure Theory – Octahedral Shear Stress Failure Theory – Fatigue Failure – S-N Curve

UNIT IV CONNECTIONS & FITTINGS

UNIT V STRESS ANALYSIS OF AIRCRAFT COMPONENTS
- Stresses in Beams & Shafts due to Combined Loading – Determination of Principal Stress and Maximum Shear Stress – Stress Analysis of a Wing Spar – Tapered Wings – Fuselage Skin Stress Analysis – Effect of Cut-outs – Concept of Shear Lag – Elements of Aeroelasticity

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1 Ability to solve problems using energy principles
CO2 Knowledge of elasticity equations & solution procedure using theory of elasticity approach
CO3 Knowledge of various theories of failure and their application
CO4 Ability to design riveted and bolted joints
CO5 Understanding of stress analysis procedures involving aircraft components

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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:

1. This course provides the basic knowledge on aero elastic phenomena and its impact on aircraft design.
2. This course will make students to illustrate the aeroelastic phenomena using simplified aerodynamic and structural models.
3. This course provides insight into both static and dynamic aeroelastic phenomena and possible prevention methods.
4. This course imparts knowledge on the flutter phenomena in detail.
5. This course provides the basic knowledge on prevention and control of aeroelastic Instabilities.

UNIT I AEROELASTIC PHENOMENA

- Introduction to aeroelasticity and aeroelastic phenomena – Free vibration analysis of basic structural members with different boundary conditions, analytical and approximate solutions, response of basic structural members to periodic and non-periodic forces
- Examples of aeroelastic phenomena – Galloping of transmission lines – Flow induced vibrations of tall slender structures – Instability of suspension bridges – Fluid structure interaction – The aeroelastic triangle of forces – Prevention of aeroelastic instabilities

UNIT II MODELLING OF AEROELASTIC PHENOMENA

- Influence and stiffness co-efficients – Illustration of aeroelastic phenomena using simplified aerodynamic and structural models – Different subsonic and supersonic aerodynamic models for aeroelastic analysis – Modelling techniques – Aeroelastic models in state-space format
- Flexure – torsional oscillations of beams – Governing differential equation of motion and its solution
- Bending, torsional and shear stiffness curves

UNIT III STATIC AEROELASTIC PHENOMENA

- Aileron effectiveness in terms of wing-tip helix angle – Critical aileron reversal speed – Rate of change of local pitching moment coefficient with aileron angle – Control Effectiveness – Wing deformations of swept wings

UNIT IV FLUTTER CALCULATIONS


UNIT V PREVENTION AND CONTROL


TOTAL: 45 PERIODS
COURSE OUTCOMES:
CO1 Have knowledge of the role of aeroelasticity in aircraft design.
CO2 Interpret the use of semi-rigid body assumptions and numerical methods in airplane design.
CO3 Arrive at the solutions for steady state aeroelastic problem.
CO4 Be knowledge with the concept of flutter analysis of aircraft wings.
CO5 Have knowledge on practical examples of aeroelastic problems.

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COURSE OBJECTIVES: The objectives of the course are

1. To familiarize the students with the fundamental concepts in boundary layer flow and with the governing equations of viscous flow and to introduce to students the similarity parameters of viscous flow.
2. To make students understand the methods for obtaining analytical solutions and the role of shear layers for low-speed viscous flow problems commonly found in engineering applications.
3. To introduce the basic concepts in laminar boundary layer theory and its applications in engineering to students for flows over flat and curved surfaces.
4. To give knowledge to students on the intricacies of various phenomena in turbulent boundary layers and in turbulence modelling and the utilization of turbulence models.
5. To give sufficient exposure to students on the techniques used for boundary layer control and separation aspects and also on the methods to delay or prevent transition.

UNIT I  VISCOSOUS FLOW AND THE GOVERNING EQUATIONS
Governing equations of viscous flow - Conservation of mass, momentum and energy equations - Stokes hypothesis - Navier-Stokes equations - Mathematical character of the governing equations - similarity parameters in viscous flow - dimensional analysis of governing equations - implementation of boundary conditions - vorticity in viscous flow - introduction to creeping flow and boundary layer flow.

UNIT II  VISCOSOUS FLOW EQUATIONS AND THEIR SOLUTION METHODS
Solutions of viscous flows such as Couette flows, Hagen-Poiseuille flow and Flow between rotating concentric cylinders - Solution of Combined Couette-Poiseuille Flow between parallel plates - Analysis of Creeping motion and Stokes solution for an immersed sphere - Shear layers in practical engineering problems - Definitions of Displacement thickness, momentum and energy thickness of a boundary layer.

UNIT III  INTRODUCTORY ANALYSIS OF LAMINAR BOUNDARY LAYER
Hierarchy of boundary layer equations - Solution of Prandtl’s boundary layer equations - flow over a flat plate and Flat plate Integral analysis of Karman and Integral analysis of energy equation - similarity solutions, Blasius solution for flat-plate flow - boundary layer over a curved body - Flow separation - Falkner–Skan wedge flows, Boundary layer temperature profiles for constant plate temperature - Reynold’s analogy - Integral equation of Boundary layer - Pohlhausen method - Thermal boundary layer calculations.

UNIT IV  FUNDAMENTAL ASPECTS OF TURBULENT BOUNDARY LAYER
Nature of Turbulence and how to account for turbulence effect - Two-dimensional turbulent boundary layer equations - Velocity profiles - The law of the wall - The law of the wake - Turbulent flow in pipes and channels - Turbulent boundary layer on a flat plate - Boundary layers with pressure gradient - Fundamentals of turbulence modelling - Concepts of Eddy Viscosity, mixing length - Classification of Turbulence models.

UNIT V  CONTROL METHODS FOR BOUNDARY LAYER
Practical control methods for laminar boundary layer - Motion of the solid wall - Acceleration of the boundary layer - Injection of mass and momentum in boundary layer - Suction - Injection of different gas - Prevention and delay of transition - Cooling of the wall - Boundary layer suction - Injection of a different gas - Introduction to moving and chemically reacting boundary layers and their control.

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

CO1 To understand the basic fluid dynamic character of viscous flows and apply the boundary conditions required for obtaining the solutions
CO2 To apply the governing equations of viscous flows for engineering applications and understand the importance of various terms in the equations
CO3 To understand the importance & application of boundary layers in engineering problems and use the boundary solutions for component design
CO4 To evaluate the nature of the boundary layer and analyze the velocity and temperature profiles and will be able to use boundary layer analysis for conjugate heat transfer problems
CO5 To understand the nature of turbulent flows and will be able to distinguish between laminar and turbulent flows for application to engineering problems
CO6 To apply boundary layer control methods for prevention of separation and delay the transition for drag reduction in aeronautical and aerospace applications

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COURSE OBJECTIVES:
1. To introduce the mathematical modelling of systems and understand the basics of Fly-by-wire control.
2. To introduce open loop and closed loop systems and analyses in time domain and frequency domain.
3. To introduce the transient and steady state characteristics of a system.
4. To impart the knowledge on the concept of stability and the various methods to analyze stability in both time and frequency domain.
5. To introduce about the design of various Autopilots.

UNIT I    INTRODUCTION TO AIRCRAFT CONTROL

UNIT II    OPEN AND CLOSED LOOP SYSTEMS
Feedback control systems – Control system components - Block diagram representation of control systems, Reduction of block diagrams, Signal flow graphs, Output to input ratios.

UNIT III    TRANSIENT AND STEADY STATE CHARACTERISTICS
Response of systems to different inputs viz., Step impulse, pulse, parabolic and sinusoidal inputs, Time response of first and second order systems, steady state errors and error constants of unity feedback circuit.

UNIT IV    CONCEPT OF STABILITY
Necessary and sufficient conditions, Routh-Hurwitz criteria of stability, Root locus and Bode techniques, Concept and construction, frequency response.

UNIT V    AUTOPILOT

COURSE OUTCOMES
Students will be able to:
CO1 Understand and apply classical and modern feedback control methods to various systems especially Flight control system and concepts of FBW systems.
CO2 Acquire knowledge on open and closed loop systems and various forms of representations.
CO3 Understand the Transient and steady state analysis and their characteristics.
CO4 Apply the concepts of frequency responses for the practical systems and Acquire in-depth knowledge about Stability analysis.
CO5 Develop and design various Autopilots in both longitudinal and lateral modes.

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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

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 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 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

UNIT II ATTITUDE SENSORS AND CONTROL ACTUATORS
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

UNIT IV RELATIVE NAVIGATION SYSTEMS

UNIT V ATTITUDE DYNAMICS AND STABILIZATION SCHEMES
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:

1. Gain a comprehensive understanding of the fundamental principles, functions, and regulatory framework of air traffic control.
2. Develop an understanding of the various air traffic control systems and surveillance technologies used for aircraft tracking and monitoring.
3. Acquire knowledge of air traffic flow management principles and techniques to optimize airspace capacity and maintain efficient air traffic flow.
4. Understand the communication systems and protocols used in air traffic control and their critical role in ensuring effective coordination and information exchange.
5. Recognize the importance of safety management systems and human factors considerations in maintaining a safe and error-free air traffic control environment.

UNIT I  INTRODUCTION TO AIR TRAFFIC CONTROL  9

UNIT II  AIR TRAFFIC CONTROL SYSTEMS AND SURVEILLANCE  9

UNIT III  FLIGHT INFORMATION SYSTEMS  9

UNIT IV  AERODROME DATA  9

UNIT V  NAVIGATION , COMMUNICATION AND OTHER SERVICES  9
Aerodrome data – Basic terminology – Aerodrome reference code – Aerodrome reference point – Aerodrome elevation – Aerodrome reference temperature – Instrument runway, physical Characteristics; length of primary / secondary runway – Width of runways – Minimum distance between parallel runways etc. – obstacles restriction- Aeronautical mobile service- Aeronautical fixed service-Surface movement control service- Aeronautical radio navigation service

TOTAL : 45 PERIODS
COURSE OUTCOMES:

CO1 Demonstrate knowledge of the roles, responsibilities, and operational procedures of air traffic control personnel, and apply them to ensure safe and efficient air traffic management.

CO2 Evaluate the capabilities and limitations of different surveillance systems, such as radar, Automatic Dependent Surveillance-Broadcast (ADS-B), and satellite-based surveillance, for effective air traffic control and enhanced situational awareness.

CO3 Explore the flight information systems, emergency procedure and air rules followed by air traffic control systems.

CO4 Describe the aerodrome data.

CO5 Demonstrate proficiency in using standard phraseology, communication procedures, and Controller-Pilot Data Link Communications (CPDLC) to facilitate clear and accurate communication between air traffic control and pilots.

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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, analyse 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.

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Course Objectives:

1. To get insight into the basic aspects of aircraft rules and certifications.
2. To gain knowledge on the basic concepts of airworthiness.
3. To learn the basic aspects on certification and publication procedures.
4. To impart knowledge on licensing and material selections.
5. To provide with the concepts of case studies and civil aviation requirements.

Unit I: Introduction to Aircraft Rules and Certifications


Unit II: C.A.R Series ‘A’ & ‘B’

Responsibilities of operators / owners; Procedure of CAR issue, amendments etc., Objectives and targets of airworthiness directorate; Airworthiness regulations and safety oversight of engineering activities of operators. C.A.R. SERIES B – Deficiency list (MEL and CDL); Preparation and use of cockpit check list and emergency list.

Unit III: C.A.R. Series ‘C’ & ‘D’

Defect recording, reporting, investigation, rectification and analysis; Flight report; Reporting and rectification of defects observed on aircraft; Analytical study of in-flight readings & recordings; Maintenance control by reliability Method. C.A.R. SERIES ‘D’ – Reliability Programmes (Engines); Aircraft maintenance programme & their approval; On condition maintenance of reciprocating engines; TBO – Revision programme; Maintenance of fuel and oil uplift and consumption records – Light aircraft engines; Fixing routine maintenance periods and component TBOs – Initial & revisions.

Unit IV: C.A.R. Series ‘E’ & ‘F’

Approval of organizations in categories A, B, C, D, E, F, & G - Requirements of infrastructure at stations other than parent base. C.A.R. SERIES ‘F’ – Procedure relating to registration of aircraft; Procedure for issue / revalidation of Type Certificate of aircraft and its engines / propeller; Issue / revalidation of Certificate of Airworthiness; Requirements for renewal of Certificate of Airworthiness.

Unit V: C.A.R. Series ‘L’ & ‘M’

Issue of AME Licence, its classification and experience requirements, Mandatory Modifications / Inspections.

Total: 45 Periods

Course Outcomes:

CO1 To realise the importance of aircraft rules and certifications
CO2 To get exposure on the basic concepts of airworthiness standards.
CO3 To develop test flight and Certification.
CO4 To carry out inspections and can identify the approved materials.
CO5 To analyse the case studies and realise the importance of civil aviation requirements.

References:
3. DGCA, “Civil Aviation Requirements with latest Amendment (Section 2 Airworthiness)” New Delhi 2000, – Published by, The English Book Store, 17-1
4. DGCA, “Aeronautical Information Circulars (relating to Airworthiness)” 2000

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[Signature]

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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
- Basic Concepts & Terminology
- Degrees of Freedom
- Types of Vibration
- Spring, Mass & Damping Elements
- Free Vibration of a Single Degree of Freedom System
- Harmonic Motion
- Effect of Damping
- Different Types of Damping

UNIT II  FORCED VIBRATION OF A SINGLE DEGREE OF FREEDOM SYSTEM
- Harmonic Excitation
- Response of a Undamped SDOF System Under Harmonic Force
- Response of a Damped SDOF System Under Periodic Force
- Base Excitation
- Response of a System Under Rotating Unbalance
- Convolution Integral
- Impulse Response
- Practical Examples
- Response due to Arbitrary Excitation

UNIT III  TWO DEGREE OF FREEDOM SYSTEMS
- Practical Examples
- Modeling
- Governing Equations of Motion
- Free Vibration Analysis of Translational and Torsional Systems
- Frequency Response Curves
- Resonance
- Coordinate Coupling & Principal Coordinates
- Principal Modes of Vibration
- Orthogonality of Mode Shapes
- Effect of Damping
- Design of a Vibration Absorber

UNIT IV  MULTI DEGREE OF FREEDOM SYSTEMS
- System Equations in Matrix Form
- Use of Lagrange's Equations
- Generalized Coordinates
- Influence Coefficients
- Eigenvalue Problem
- Natural Frequencies
- Orthogonality of Normal Modes
- Matrix Iteration Method
- Rayleigh Method
- Holzer Methods
- Jacobi Method

UNIT V  VIBRATION OF CONTINUOUS SYSTEMS
- Transverse Vibrations of a Cable
- Axial Vibrations of a Bar
- Torsional Vibrations of a Shaft
- Lateral Beam Vibration
- Membrane Vibration
- Rayleigh’s Method
- Rayleigh-Ritz Method
- Beams With Concentrated Loads
- Natural Frequencies and Mode Shapes

TOTAL: 45 PERIODS

COURSE OUTCOMES:
CO1 Ability of a student to model a given physical system into a single or multi-degree of freedom system.
CO2 Solve problems involving single and multi degrees of freedom
CO3 Analyze the vibration characteristics of both discrete and continuous systems
CO4 Ability to extract natural frequencies natural frequencies of a multi degree of freedom system using approximate methods
CO5 Students are able predict the response of a physical system to initial excitation
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