ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS - 2015
CHOICE BASED CREDIT SYSTEM
M.E. AERONAUTICAL ENGINEERING (FT/PT)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. **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.

II. **PEO 2:** Successful Career Development: Graduates of the programme will have successful technical and managerial career in Aeronautical Engineering industries and the allied management.

III. **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 Aviation industries.

IV. **PEO 4:** Sustainable interest for Lifelong learning: Graduates of the programme will have sustained interest to learn and adapt new technology developments to meet the changing industrial scenarios.

PROGRAMME OUTCOMES (POs)

On successful completion of the programme,

1. Post Graduate will acquire the ability to design and conduct experiments, as well as to analyze and interpret data in the field of Aeronautical Engineering.
2. Post Graduate will have the ability to design a system or a component to meet the design requirements with constraints exclusively meant for Aeronautical Engineering.
3. Post Graduate will become familiar with modern engineering tools and analyze problems within the domains of Aeronautical Engineering.
4. Post Graduate will acquire an understanding of professional and ethical responsibility with reference to their career in the field of Aeronautical Engineering and other allied professional fields.
5. Post Graduate will be able to communicate effectively both in verbal and nonverbal forms.
6. Post Graduate will be trained towards developing and understanding the importance of design and development of Airplanes from system integration point of view.
7. Post Graduate will be capable of understanding the value of lifelong learning.
8. Post Graduate will exhibit the awareness of contemporary issues focusing on the necessity to develop new materials, design and testing methods for the solution of problems related to aircraft industry.

9. Post Graduate will have a firm scientific, technological and communication base that helps him to find a placement in the aircraft industry and Research & Development organizations related to Aeronautical Engineering and other professional fields.

10. Post Graduate will be capable of doing doctoral studies and research in inter and multidisciplinary areas.

Mapping of PEOs with POs

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|      |      | Airplane Performance, stability and control | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Computational Fluid Dynamics for Aerospace applications | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| YEAR | SEM 3 | Professional Elective-II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Professional Elective-III | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Professional Elective-IV | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      | YEAR 2 | Technical Seminar | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Project phase-I | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      | SEM 4 | Project Phase-II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Project Phase-II | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| PROFES | ELECTIVES | Chemical Rocket Technology | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Computational Heat Transfer | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Design of Turbo machines | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
|      |      | Experimental Aerodynamics | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
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### M.E. AERONAUTICAL ENGINEERING (FT/PT)

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OBJECTIVE:

- To impart knowledge to students on basic governing equations of elasticity, solving of 2D problems in Cartesian and polar coordinates and also to introduce various theories and methods to solve torsion related problems.

UNIT I  INTRODUCTION  
Definition, notations and sign conventions for stress and strain – Stress - strain relations, strain-displacement relations- Elastic constants.

UNIT II  BASIC EQUATIONS OF ELASTICITY  
Equations of equilibrium – Compatibility equations in strains and stresses –Boundary Conditions - Saint-Venant’s principle - Stress ellipsoid – Stress invariants – Principal stresses in 2-D and 3-D.

UNIT III  2- D PROBLEMS IN CARTESIAN COORDINATES  
Plane stress and plain strain problems - Airy’s stress function – Biharmonications – 2-D problems– Cantilever and simply supported beams.

UNIT IV  2- D PROBLEMS IN POLAR COORDINATES  

UNIT V  TORSION  
Stress function approach and warping function approach – Torsion of Circular, Elliptical and Triangular sections - Membrane analogy.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will understand the basic concepts of obtaining exact solution for structural mechanics problems.

REFERENCES

OBJECTIVES:

- To impart knowledge to students about fundamental principles of aircraft hypersonic and rocket propulsion and also to make them familiarize with electric nuclear and solar space propulsion methods.

UNIT I  ELEMENTS OF AIRCRAFT PROPULSION  
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 of turboprop, turbofan and turbojet , Ram jet, Scram jet – Methods of Thrust augmentation.
UNIT II  PROPELLER THEORY  12
Momentum theory, Blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters, prediction of static thrust- and in flight, negative thrust, prop fans, ducted propellers, propeller noise, propeller selection, propeller charts.

UNIT III  INLETS, NOZZLES AND COMBUSTION CHAMBERS  12

UNIT IV  AXIAL FLOW COMPRESSORS, FANS AND TURBINES  12

UNIT V  ROCKET AND ELECTRIC PROPULSION  12

OUTCOMES:
• Upon completion of the course, students will learn the principles of operation and design of aircraft and spacecraft power plants.

REFERENCES
UNIT II SKEAR FLOW IN OPEN SECTIONS
Shear stresses in beams – Shear flow in stiffened panels - Shear flow in thin walled open tubes – Shear centre – Shear flow in open sections with stiffeners.

UNIT III SKEAR FLOW IN CLOSED SECTIONS
Shear flow in closed sections with stiffeners – Angle of twist - Shear flow in two flange and three flange box beams – Shear centre - Shear flow in thin walled closed tubes - Bredt-Batho theory - Torsional shear flow in multi cell tubes - Flexural shear flow in multi cell stiffened structures.

UNIT IV STABILITY PROBLEMS
Stability problems of thin walled structures – Buckling of sheets under compression, shear, bending and combined loads - Crippling stresses by Needham’s and Gerard’s methods–Sheet stiffener panels-Effective width, Inter rivet and sheet wrinkling failures-Tension field web beams(Wagner’s).

UNIT V ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS
 Loads on Wings – Schrenk’s curve - Shear force, bending moment and torque distribution along the span of the Wing. Loads on fuselage - Shear and bending moment distribution along the length of the fuselage. Analysis of rings and frames.

OUTCOMES:
Upon completion of the course, students will get knowledge on different types of beams and columns subjected to various types of loading and support conditions with particular emphasis on aircraft structural components.

REFERENCES

AL7153 FLIGHT VEHICLE AERODYNAMICS

OBJECTIVES:
To introduce the students the fundamental concepts and topic related to aerodynamics of flight vehicles like fundamental forms of flow, aerodynamic coefficient, incompressible and compressible flow theories, viscous flow measurements and various configuration of aircraft and wings.

UNIT I INTRODUCTION TO AERODYNAMICS
Hot air balloon and aircrafts, Various types of airplanes, Wings and airfoils, lift and Drag, Centre of pressure and aerodynamic centre, Centre 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
Conformal Transformation, Kutta condition, Karman – Trefftz profiles, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot - Savart law, lifting line theory
UNIT III COMpressible FLOW THEORy 9
Compressibility, Isentropic flow through nozzles, shocks and expansion waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, small perturbation theory, Prandtl- Glauert Rule, Linearised supersonic flow, Method of characteristics

UNIT IV AIRFOILS, WINGS AND AIRPLANE CONFIGURATION IN HIGH SPEED FLOWS 6
Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, Transonic area rule, Swept wings (ASW and FSW), supersonic airfoils, wave drag, delta wings, Design considerations for supersonic airplanes

UNIT V VISCous FLOW AND FLOW MEASUREMENTS 9

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course, students will understand the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime.

REFERENCES

AL7154 ROCKETRY AND SPACE MECHANICS

OBJECTIVES:
- To familiarize the students on fundamental aspects of rocket propulsion, multi staging of rocket vehicle and spacecraft dynamics.

UNIT I ORBITAL MECHANICS 9

UNIT II SATELLITE DYNAMICS 9
Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations- methods to calculate perturbations- Hohmann orbits – calculation of orbit parameters– Determination of satellite rectangular coordinates from orbital elements

UNIT III ROCKET MOTION 10
Principle of operation of rocket motor - thrust equation – one dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields – Description of vertical
inclined and gravity turn trajectories determinations of range and altitude – simple approximations to burnout velocity.

UNIT IV ROCKET AERODYNAMICS

UNIT V STAGING AND CONTROL OF ROCKET VEHICLES
Need for multi staging of rocket vehicles – multistage vehicle optimization – stage separation dynamics and separation techniques- aerodynamic and jet control methods of rocket vehicles - SITVC.

OUTCOMES:
- Upon completion of the course, students will have an idea about solar system, basic concepts of orbital mechanics with particular emphasis on interplanetary trajectories.

REFERENCES

MA7161 ADVANCED MATHEMATICAL METHODS

OBJECTIVES:
- To familiarize the students in differential equations for solving boundary value problems associated with engineering applications.
- To expose the students to calculus of variation, conformal mappings and tensor analysis.

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

UNIT II FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS

UNIT III CALCULUS OF VARIATIONS
Concept of variation and its properties – Euler’s equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – problems with constraints - Direct methods: Ritz and Kantorovich methods.
UNIT IV     CONFORMAL MAPPING AND APPLICATIONS
Introduction to conformal mappings and bilinear transformations - Schwarz - Christoffel transformation – Transformation of boundaries in parametric form- Physical applications: Fluid flow heat flow problems.

UNIT V     TENSOR ANALYSIS

TOTAL: 60 PERIODS

OUTCOME:
- This subject helps to develop the mathematical methods of applied mathematics and mathematical physics with an emphasis on calculus of variation and integral transforms.

TEXT BOOKS:

REFERENCES:

AL7161     AERODYNAMICS PROPULSION LABORATORY     L T P C
0 0 4 2

OBJECTIVE:
- To expose students with a practical knowledge on various aerodynamic principles related to inviscid incompressible fluids, aerodynamic measurement techniques and testing of sub systems and components of aircraft at low speed.

LIST OF EXPERIMENTS :
1. Calibration of subsonic wind tunnel
2. Pressure distribution over a cambered aerofoil section
3. Force and moment measurements using wind tunnel balance
4. Pressure distribution over a wing of symmetric aerofoil section
5. Pressure distribution over a wing of cambered aerofoil section
6. Supersonic flow visualization studies
7. Total pressure measurements along the jet axis of a circular supersonic jet
8. Cold flow studies of a wake region behind flame holders
9. Wall pressure measurements of a noncircular combustor
10. Wall pressure measurements of a subsonic diffuser
11. Cascade testing of compressor blades.
Only 10 experiments need to be conducted.

TOTAL: 60 PERIODS

OUTCOMES:
- Upon completion of the course, students will be in a position to use wind tunnel for pressure and force measurements on various models.

ONLY 10 EXPERIMENTS WILL BE CONDUCTED

LABORATORY EQUIPMENTS REQUIREMENTS
1. Subsonic wind tunnel
2. Rough and smooth cylinder
3. Symmetrical Cambered aerofoil
4. Wind tunnel balance
5. Schlieren system
6. Pressure Transducers

AL7201 ADVANCED PROPULSION SYSTEMS

OBJECTIVES:
- To familiarize the students on advanced air breathing propulsion systems like air augmented rockets, scramjets and also to introduce the students various technical details and operating principles of nuclear and electric propulsion.

UNIT I THERMODYNAMIC CYCLE ANALYSIS OF AIR-BREATHING PROPULSION SYSTEMS
8
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.

UNIT II RAMJETS AND AIR AUGMENTED ROCKETS
8
Preliminary performance calculations – Diffuser design with and without spike, Supersonic inlets – combustor and nozzle design – integral Ram rocket.

UNIT III SCRAMJET PROPULSION SYSTEM
12

UNIT IV NUCLEAR PROPULSION
9

UNIT V ELECTRIC AND ION PROPULSION
8

TOTAL: 45 PERIODS
OUTCOMES:
- Upon completion of the course, students will learn in detail about gas turbines, ramjet, fundamentals of rocket propulsion and chemical rockets.

REFERENCES

AL7202 AIRPLANE PERFORMANCE, STABILITY AND CONTROL

OBJECTIVE:
- To impart knowledge to students on aircraft performance in level, climbing, gliding and accelerated flight modes and also various aspects of stability and control in longitudinal, lateral and directional modes.

UNIT I PRINCIPLES OF FLIGHT

UNIT II AIRCRAFT PERFORMANCE IN LEVEL, CLIMBING AND GLIDING FLIGHTS
Straight and level flight, Thrust required and available, Power required and available, Effect of altitude on thrust and power, Conditions for minimum drag and minimum power required, Gliding and Climbing flight, Range and Endurance.

UNIT III ACCELERATED FLIGHT
Take off and landing performance, Turning performance, horizontal and vertical turn, Pull up and pull down, maximum turn rate, V-n diagram with FAR regulations.

UNIT IV LONGITUDINAL STABILITY AND CONTROL
Degrees of freedom of a system, static and dynamic stability, static longitudinal stability, Contribution of individual components, neutral point, static margin, Hinge moment, Elevator control effectiveness, Power effects, elevator angle to trim, elevator angle per g, maneuver point, stick force gradient, aerodynamic balancing, Aircraft equations of motion, stability derivatives, stability quartic, Phugoid motion.

UNIT V LATERAL, DIRECTIONAL STABILITY AND CONTROL
Yaw and side slip, Dihedral effect, contribution of various components, lateral control, aileron control power, strip theory, aileron reversal, weather cock stability, directional control, rudder requirements, dorsal fin, One engine inoperative condition, Dutch roll, spiral and directional divergence, autorotation and spin.

OUTCOMES:
- Upon completion of the course, students will understand the static, dynamic longitudinal, directional and lateral stability and control of airplane, effect of maneuvers.

REFERENCES
AL7203  
FINITE ELEMENT ANALYSIS  

**OBJECTIVES:**
- To make students learn using Finite element techniques to solve problems related to discrete, continuum and isoparametric elements. And also to introduce solution schemes for static, dynamic and stability problems.

**UNIT I**  
**INTRODUCTION**  
12  

**UNIT II**  
**DISCRETE ELEMENTS**  
14  

**UNIT III**  
**CONTINUUM ELEMENTS**  
14  

**UNIT IV**  
**ISOPARAMETRIC ELEMENTS**  
12  
Definition and use of different forms of 2-D and 3-D elements. - Formulation of element stiffness matrix and load vector.Solution for 2-D problems (static analysis and heat transfer) using software packages.

**UNIT V**  
**SOLUTION SCHEMES**  
8  
Different methods of solution of simultaneous equations governing static, dynamics and stability problems. General purpose Software packages.

**OUTCOMES:**
- Upon completion of the course, students will learn the concept of numerical analysis of structural components

**REFERENCES**
AL7251 COMPOSITE MATERIALS AND STRUCTURES

OBJECTIVE:

- To impart knowledge to the students on the macro mechanics of composite materials, analysis and manufacturing methods of composite materials and introduce failure theories of composites.

UNIT I INTRODUCTION

UNIT II MACROMECHANICS
Hooke’s law for orthotropic and anisotropic materials-Lamina stress-strain relations referred to natural axes and arbitrary axes.

UNIT III ANALYSIS OF LAMINATED COMPOSITES
Governing equations for anisotropic and orthotropic plates- Angle-ply and cross ply laminates-Analysis for simpler cases of composite plates and beams - Interlaminar stresses.

UNIT IV MANUFACTURING & FABRICATION PROCESSES

UNIT V OTHER METHODS OF ANALYSIS AND FAILURE THEORY
Netting analysis- Failure criteria-Flexural rigidity of Sandwich beams and plates – composite repair- AE technique.

OUTCOMES:
- Upon completion of the course, students will understand the fabrication, analysis and design of composite materials & structures

REFERENCES
OBJECTIVES:
- To introduce to the students various numerical solution methods pertaining to grid generation, time dependant and panel methods and also techniques pertaining to transonic small perturbation force.

UNIT I  NUMERICAL SOLUTIONS OF SOME FLUID DYNAMICAL PROBLEMS  12

UNIT II  GRID GENERATION  12

UNIT III  TRANSONIC RELAXATION TECHNIQUES  12
Small perturbation flows, Transonic small perturbation (TSP) equations, Central and backward difference schemes, conservation equations and shock point operator, Line relaxation techniques, Acceleration of convergence rate, Jameson’s rotated difference scheme -stretching of coordinates, shock fitting techniques Flow in body fitted coordinate system. Numerical solution of 1-D conduction- convection energy equation using time dependent methods using both implicit and explicit schemes – application of time split method for the above equation and comparison of the results.

UNIT IV  TIME DEPENDENT METHODS  12

UNIT V  PANEL METHODS  12
Elements of two and three dimensional panels, panel singularities. Application of panel methods to incompressible, compressible, subsonic and supersonic flows. Numerical solution of flow over a cylinder using 2-D panel methods using both vertex and source panel methods for lifting and non lifting cases respectively.

OUTCOMES:
Upon completion of the course, students will learn the flow of dynamic fluids by computational methods.

REFERENCES
OBJECTIVES:
- To impart practical knowledge to the students on calibration of photoelastic materials, determination of elastic constant for composite lamina, unsymmetrical bending of beams, determination of shear centre locations for closed and open sections and experimental studies.

LIST OF EXPERIMENTS
1. Constant strength Beams
2. Buckling of columns
3. Unsymmetrical Bending of Beams
4. Shear Centre Location for Open Section
5. Shear Centre Location for Closed Section
6. Flexibility Matrix for Cantilever Beam
7. Combined Loading
8. Calibration of Photo Elastic Materials
10. Vibration of Beams with Different Support Conditions
11. Fabrication of composite laminates.
12. Characterization of composite laminates
13. Wagner beam

NOTE: Any TEN experiments will be conducted out of 13.

TOTAL: 60 PERIODS

OUTCOMES:
- Upon completion of the course, students will learn the concept of numerical analysis of structural components

LABORATORY EQUIPMENTS REQUIREMENTS
1. Constant strength beam setup
2. Column setup
3. Unsymmetrical Bending setup
4. Experimental setup for location of shear centre (open & close section)
5. Cantilever beam setup
6. Experimental setup for bending and torsional loads
7. Diffuser transmission type polariscope with accessories
8. Experimental setup for vibration of beams
10. Wagner beam setup

AL7001 ADVANCED COMPUTATIONAL FLUID DYNAMICS AND HEAT TRANSFER

OBJECTIVES:
- Students will learn computational methods pertaining to compressible, incompressible flow using finite volume method, students will also learn modern computing methods and the computation of chemically reacting flows and combustion.

UNIT I COMPUTATION OF INCOMPRESSIBLE VISCOUS FLOWS:
General - Artificial compressibility methods - Pressure correction methods - Semi-implicit method for pressure linked equations (SIMPLE) - Pressure implicit with splitting of operators - Marker and Cell (MAC) method - Vortex methods.
UNIT II COMPUTATION OF COMPRESSIBLE INVISCID FLOWS: 9
Potential equation - Euler equations - Central schemes with combined space time discretization - Central schemes with independent space time discretization - First order upwind schemes - Second order upwind schemes with low resolution - second order upwind schemes with high resolution - Essentially nonoscillatory scheme - Flux corrected transport schemes.

UNIT III COMPUTATION OF COMPRESSIBLE VISCOUS FLOWS: 9
Navier-Stokes system of equations - Preconditioning process for compressible and incompressible - Flowfield dependent variation methods - Artificial viscosity flux limiters - Fully implicit high order accurate schemes - Point implicit methods

UNIT IV MODERN COMPUTING METHODS 9
Domain decomposition methods - Multigrid methods - Parallel processing - Development of parallel algorithms - Parallel processing with domain decomposition and multigrid methods - Load balancing - Solution of Poisson equation with domain decomposition parallel processing - Solution of Navier-Stokes system of equations with multithreading.

UNIT V COMPUTATION OF CHEMICALLY REACTIVE FLOWS AND COMBUSTION 9
Governing equations in reactive flows - Chemical equilibrium computations - Solution methods of stiff chemical equilibrium equations - Applications to chemical kinetics calculations - Hypersonic reactive flows - Vibrational and electronic energy in non-equilibrium.

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course students will learn the use of and application of finite volume methods for both incompressible and compressible flows for solution of flow problems and combustion problems.

REFERENCES

AL7002 ADVANCED FLIGHT STRUCTURES 3 0 0 3

OBJECTIVES:
To make students learn the methodology to carry out structural design and analysis of advanced aerospace structures used in modern aircraft, missiles and spacecraft.

UNIT I REVIEW 6
Aerospace Structural Design Principles (Energy Methods, Beam Bending)

Unit II PLATE THEORY 9
Thin Plate Theory, Stress Resultants and Kinematics - Thin Plate Governing Equations and Boundary Conditions

UNIT III ADVANCED CONCEPTS IN BUCKLING OF LIGHTWEIGHT STRUCTURES 6
Thin Plate Solutions and Plate Buckling - Local and Global-Local Buckling of Thin Walled Structures

23
UNIT IV
COMPOSITE MATERIALS

UNIT V
INTRODUCTORY STRUCTURAL DYNAMICS AND AERO ELASTICITY
Introduction to Structural Vibration, Beam Free Vibration - Forced Response of a Beam Structure - Airfoil and Wing Divergence, Wing Divergence, Swept Wings - Control Effectiveness and Reversal - Airfoil Flutter, Wing Flutter, Swept Wings

TOTAL: 45 PERIODS

OUTCOMES:
• Upon completion of the course students will be able to carry out structural analysis of complex aerospace structures.

TEXT BOOK:

REFERENCE BOOKS:

AL7003
AERO ELASTICITY
L T P C
3 0 0 3

OBJECTIVES:
• To make the students understand aero elastic phenomena, flutter and to make them to solve steady state aero elastic problems.

UNIT I
AEROELASTIC PHENOMENA

UNIT II
DIVERGENCE OF A LIFTING SURFACE

UNIT III
STEADY STATE AEROLASTIC PROBLEMS

UNIT IV
FLUTTER PHENOMENON
Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow.

**UNIT V EXAMPLES OF AEREOELASTIC PROBLEMS**

Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges.

**TOTAL: 45 PERIODS**

**OUTCOMES:**
Upon completion of the course, Students can understand the theoretical concepts of material behaviour with particular emphasis on their elasticity property.

**REFERENCES**

**AL7004 AEROSPACE MATERIALS**

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**OBJECTIVES**
- To impart knowledge to the students on mechanical behaviour, corrosion & heat treatment of aerospace materials and also to expose them to applications of ceramic & composites and high temperature characterization.

**UNIT I ELEMENTS OF AEROSPACE MATERIALS**


**UNIT II MECHANICAL BEHAVIOUR OF MATERIALS**

Linear and nonlinear elastic properties – Yielding, strain hardening, fracture, Bauchinger’s effect – Notch effect testing and flaw detection of materials and components – Comparative study of metals, ceramics, plastics and composites.

**UNIT III CORROSION & HEAT TREATMENT OF METAL SAND ALLOYS**


**UNIT IV CERAMICS AND COMPOSITES**

UNIT V HIGH TEMPERATURE MATERIALS CHARACTERIZATION
Classification, production and characteristics—Methods and testing—Determination of mechanical and thermal properties of materials at elevated temperatures—Application of these materials in Thermal protection systems of Aerospace vehicles—super alloys—High temperature material characterization.

OUTCOMES:
- Upon completion of this course, students will understand the advanced concepts of aerospace materials and to provide the necessary mathematical knowledge that are needed in understanding their significance and operation. The students will have an exposure on various topics such elements of aerospace materials, mechanical behavior of materials, ceramics and composites and will be able to deploy these skills effectively in the understanding of aerospace materials.

REFERENCES
4. Raghavan, V., Materials Science and Engineering, Prentice Hall of India, New Delhi, 1993

AL7005 AIRCRAFT DESIGN

OBJECTIVES:
- To impart knowledge to the students on various types of power plant types and also to expose them principles of aerodynamics and structural design aspects.

UNIT I REVIEW OF DEVELOPMENTS IN AVIATION
Categories and types of aircrafts—various configurations—Layouts and their relative merits—strength, stiffness, fail safe and fatigue requirements—Maneuvering load factors—Gust and maneuverability envelopes—Balancing and maneuvering loads on tail planes.

UNIT II POWER PLANT TYPES AND CHARACTERISTICS
Characteristics of different types of power plants—Propeller characteristics and selection—Relative merits of location of power plant.

UNIT III PRELIMINARY DESIGN
Selection of geometric and aerodynamic parameters—Weight estimation and balance diagram—Drag estimation of complete aircraft—Level flight, climb, takeoff and landing calculations—range and endurance—static and dynamic stability estimates—control requirements.

UNIT IV SPECIAL PROBLEMS
Layout peculiarities of subsonic and supersonic aircraft—optimization of wing loading to achieve desired performance—loads on undercarriages and design requirements.

UNIT V STRUCTURAL DESIGN
Estimation of loads on complete aircraft and components—Structural design of fuselage, wings and undercarriages, controls, connections and joints. Materials for modern aircraft—Methods of analysis, testing and fabrication.

TOTAL: 45 PERIODS
OUTCOMES:
- Upon completion of the course, students will get the basic concept of aircraft design.

REFERENCES

AL7006 DESIGN OF TURBO MACHINES

OBJECTIVES:
- To introduce the students the basic design aspects of gas turbine engine components like compressor, turbine, combustion chamber, inlet and nozzle and also to introduce them to engine parametric analysis.

UNIT I INTRODUCTION TO TURBO MACHINES
Introduction to turbo machines - Types - Dimensional Analysis - Dimensions and Equations - The Buckingham \( \pi \) theorem - Model testing - Energy transfer - Components - Euler turbine equations.

UNIT II HYDRAULIC PUMPS & TURBINES
Centrifugal pumps - Slip factor - Pump losses - effect of blade shape - Volute Collector - Vane and Vane less diffuser - Cavitation - Suction specific speed - Axial flow pump - Pumping system design - life cycle analysis - Changing pump Speed Operation - Multi pump operation.
Pelton wheel - velocity triangles - Losses and Efficiencies - Reaction turbines - Losses-characteristics - Axial flow turbine - Cavitation.

UNIT III CENTRIFUGAL COMPRESSORS AND FANS
Centrifugal Compressor - Effect of Blade Shape on Performance - Velocity diagrams - Slip factor - Work done - diffuser - Compressibility effects - Mach number in the Diffuser - Centrifugal Compressor Characteristics - Stall - Surging - Chocking

UNIT IV AXIAL FLOW COMPRESSORS AND FANS
Velocity diagrams - Degree of reaction - Stage Loading - Lift and Drag Characteristics - Cascade nomenclature and terminology - 3- D Consideration - Multi Stage Performance - Axial Compressor Characteristics

UNIT V AXIAL FLOW AND RADIAL FLOW TURBINES
Introduction - velocity triangles and work output - Degree of reaction Blade loading coefficient - Stator and rotor losses - Free vortex design - Constant angle design.
Radial flow turbine - Velocity and Thermodynamic analysis - Spouting Efficiency - Turbine Efficiency - Application Specific Speed

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course students will be able to carry out the preliminary design of gas turbine engine components like inlets & diffusers, combustion chambers, compressors and turbines.
REFERENCES:

AL7007 EXPERIMENTAL AERODYNAMICS  
L T P C  
3 0 0 3

OBJECTIVES:

- To make the students learn basic wind tunnel measurements and flow visualization methods, flow measurement variables and data acquisition method pertaining to experiments in aerodynamics.

UNIT I BASIC MEASUREMENTS IN FLUID MECHANICS


UNIT II WIND TUNNEL MEASUREMENTS


UNIT III FLOW VISUALIZATION AND ANALOGUE METHODS


UNIT IV PRESSURE, VELOCITY AND TEMPERATURE MEASUREMENTS

Pitot-Static tube characteristics - Velocity measurements - Hot-wire anemometry – Constant current and Constant temperature Hot-Wire anemometer – Hot-film anemometry – Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV) – Pressure Sensitive Paints - Pressure measurement techniques - Pressure transducers – Temperature measurements.

UNIT V DATA ACQUISITION SYSTEMS AND UNCERTAINTY ANALYSIS

Data acquisition and processing – Signal conditioning - Estimation of measurement errors – Uncertainty calculation - Uses of uncertainty analysis.

OUTCOMES:

- Upon completion of the course, students will learn about the measurement of flow properties in wind tunnels and their associated instrumentation.

REFERENCES
AL7008  EXPERIMENTAL STRESS ANALYSIS  LT PC

3 0 0 3

OBJECTIVE:

- To make the students learn basic principles of operation, electrical resistance strain gauges, photoelasticity and interferometric techniques and non-destructive methods.

UNIT I  INTRODUCTION  8
Principle of measurements-Accuracy, sensitivity and range- Mechanical, Optical, Acoustical and Electrical extensometers.

UNIT II  ELECTRICAL RESISTANCE STRAIN GAUGES  12
Principle of operation and requirements-Types and their uses-Materials for strain gauge-Calibration and temperature compensation-Cross sensitivity-Rosette analysis-Wheatstone bridge-Potentiometer circuits for static and dynamic strain measurements-Strain indicators- Application of strain gauges to wind tunnel balance.

UNIT III  PRINCIPLES OF PHOTOELASTICITY  9

UNIT IV  PHOTOELASTICITY AND INTERFEROMETRY TECHNIQUES  9

UNIT V  NON DESTRUCTIVE TECHNIQUES  7
Radiography- Ultrasonics- Magnetic particle inspection- Fluorescent penetrant technique-Eddy current testing– thermography– MICRO FOCUS CT scan.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will be able to appreciate use of strain gauges and its principles, principle of photo elasticity and its use, NDT techniques

REFERENCES
AL7009  HELICOPTER AERODYNAMICS  L T P C  3 0 0 3

OBJECTIVES:

- To impart knowledge to the students and fundamental aspects of helicopter aerodynamics, performance of helicopters, stability and control aspects and also to expose them basic and aerodynamic design aspects.

UNIT I  INTRODUCTION  7
Types of rotorcraft – autogyro, gyrodyne, helicopter, Main rotor system – articulated, semi rigid, rigid rotors, Collective pitch control, cyclic pitch control, anti torque pedals.

UNIT II  HELICOPTER AERODYNAMICS  12
Momentum / actuator disc theory, Blade element theory, combined blade element and momentum theory, vortex theory, rotor in hover, rotor model with cylindrical wake and constant circulation along blade, free wake model, Constant chord and ideal twist rotors, Lateral flapping, Coriolis forces, reaction torque, compressibility effects, Ground effect.

UNIT III  PERFORMANCE  9
Hover and vertical flight, forward level flight, Climb in forward flight, optimum speeds, Maximum level speed, rotor limits envelope – performance curves with effects of altitude

UNIT IV  STABILITY AND CONTROL  9
Helicopter Trim, Static stability – Incidence disturbance, forward speed disturbance, angular velocity disturbance, yawing disturbance, Dynamic Stability.

UNIT V  AERODYNAMIC DESIGN  8
Blade section design, Blade tip shapes, Drag estimation – Rear fuselage upsweep, vibration problem of Helicopter blades.

TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn about the basic ideas of evolution, performance and associated stability problems of helicopter.

REFERENCES

AL7010  HIGH TEMPERATURE GAS DYNAMICS  L T P C  3 0 0 3

OBJECTIVES:

- To make the students learn the kinetic theory of hypersonic flows and statistical thermodynamic aspects of flows at very high temperatures and also to make them familiarize the calculations transport properties of gases high temperature.

UNIT I  INTRODUCTION  8
Nature of high temperature flows – Chemical effects in air – Real perfect gases – Gibb’s free energy and entropy by chemical and non equilibrium – Chemically reacting mixtures and boundary layers.
UNIT II   STATISTICAL THERMODYNAMICS  8
Introduction to statistical thermodynamics – Relevance to hypersonic flow - Microscopic
description of gases – Boltzman distribution – Cartesian function

UNIT III  KINETIC THEORY AND HYPersonic FLOWS  9
Chemical equilibrium calculation of equilibrium composition of high temperature air – equilibrium
properties of high temperature air – collision frequency and mean free path – velocity and speed
distribution functions.

UNIT IV   INVISCID HIGH TEMPERATURE FLOWS  10
Equilibrium and non – equilibrium flows – governing equations for inviscid high temperature
equilibrium flows – equilibrium normal and oblique shock wave flows – frozen and equilibrium
flows – equilibrium conical and blunt body flows – governing equations for non equilibrium inviscid
flows.

UNIT V    TRANSPORT PROPERTIES IN HIGH TEMPERATURE GASES  10
Transport coefficients – mechanisms of diffusion – total thermal conductivity – transport
characteristics for high temperature air – radiative transparent gases – radiative transfer equation
for transport, absorbing and emitting and absorbing gases.

TOTAL: 45 PERIODS

OUTCOMES:
• Upon completion of the course, students will learn statistical thermodynamics and the
  transport properties of high temperature gases.

REFERENCES
1. John D. Anderson, Jr., Hypersonic and High Temperature Gas Dynamics, McGraw-Hill Series,
   New York, 1996.
   Series, New York, 1996.
3. William H. Heiser and David T. Pratt, Hypersonic Air breathing propulsion, AIAA Education
   Series.
5. T.K.Bose, High Temperature Gas Dynamics,

AL7011  MISSILE AERODYNAMICS  L T P C
3  0  0  3

OBJECTIVES:
• To impart knowledge to students on basic missile configurations and preliminary drag
  estimation. The objective is also to introduce slender body aerodynamics, aerodynamic
  aspects during launching phase and stability and control aspects of missile.

UNIT I   BASICS ASPECTS OF MISSILE AERODYNAMICS  9
Classification of missiles-Aerodynamics characteristics and requirements of air to air missiles, air
to surface missiles and surface to air missiles-Missile trajectories-fundamental aspects of
hypersonic aerodynamics.

UNIT II   MISSILE CONFIGURATIONS AND DRAG ESTIMATION  9
Types of Rockets and missiles-various configurations-components-forces on the vehicle during
atmospheric flight-nose cone design and drag estimation
UNIT III  AERODYNAMICS OF SLENDER AND BLUNT BODIES  9
Aerodynamics of slender and blunt bodies, wing-body interference effects-Asymmetric flow separation and vortex shedding-unsteady flow characteristics of launch vehicles- determination of aero elastic effects.

UNIT IV  AERODYNAMIC ASPECTS OF LAUNCHING PHASE  9
Booster separation-cross wind effects-specific considerations in missile launching-missile integration and separation-methods of evaluation and determination- Wind tunnel tests – Comparison with CFD Analysis.

UNIT V  STABILITY AND CONTROL OF MISSILES  9

OUTCOMES:
Upon completion of the course, Students will learn the concept of high speed aerodynamics and Configurations of missiles.

REFERENCES:

AL7012  NON DESTRUCTIVE TESTING AND EVALUATION  L T P C 3 0 0 3
OBJECTIVE:
To impart knowledge to students on the fundamentals of nondestructive testing methods and techniques, aircraft inspection methodology using NDT methods and the structural health monitoring of aerospace structures. Students will also learn modern NDT techniques like acoustic emission, ultrasonic and thermographic testing methods.

UNIT I  INTRODUCTION  9
Definition -Need for NDT— NDT in PAF—NDT application- Structure Inspection - Detecting manufacturing or service- induced damage- Structural Deterioration- Structural Deterioration - Corrosion— Fatigue (cyclic loading)— Fabrication defects— Operation and Maintenance—Unforeseen loading (overloads)- Inspection Levels- General Visual Inspection— During pre, tru or post flight- Detailed Visual Inspection (DET) - During periodic inspection- Special Detailed Inspection (SDET) - Uses of NDT Methods.

UNIT II  AIRCRAFT INSPECTION  6

UNIT III  MODERN NDT TECHNIQUES  12
Sensor Based Inspections- Principle Excitation Source Signal - Image Display Recognition Result Input transducer Measurement Signal – Image transducer Processing- Infrared and thermal testing (IR)— Impulse excitation technique (IET)— Guided wave testing (GWT)— Ellipsometry— Remote field testing (RFT)-Magnetic flux leakage testing (MFL) - Direct current potential drop.
measurement (DCPD) - Alternating current potential drop measurement (ACPD) - Alternating current field measurement (ACFM) - Electromagnetic testing (ET) – Acoustic emission testing (AE or AT)- Wire Rope NDT- Phased Array (PA) Ultrasonic’s- Thermo graphic Testing

UNIT IV  FUSELAGE INSPECTION

Digital Radiography- High Density Line Scan Solid State detectors-Flat Panel detectors (FPDs)- Pulsed Eddy Current Inspection- Shearography.

UNIT V  STRUCTURAL HEALTH MONITORING

SHM- Continuous monitoring - fatigue, corrosion, excessive loads, impact – Advantages- Production parameters– Environmental conditions– Flight parameters and conditions– Loads/Strains–Damages- Structural Health Monitoring/Management -Automated assessment and prognostic of the health of aircraft

TOTAL : 45 PERIODS

OUTCOMES:
- Upon completion of the course students will be capable of using or operating some non destructive methods like acoustic emission, ultrasonic and other structural health monitoring methods.

TEXT BOOKS:

REFERENCES:

AL7013  STRUCTURAL DYNAMICS

OBJECTIVE:
- To introduce the students the force deflection properties of structures, natural modes of vibration, principles of dynamics and energy and approximate methods for aerospace structures.

UNIT I  FORCE DEFLECTION PROPERTIES OF SYSTEMS

UNIT II  PRINCIPLES OF DYNAMICS  9
Free and forced vibrations of systems with finite degrees of freedom – Response to periodic excitation – Impulse Response Function – Convolution Integral

UNIT III  NATURAL MODES OF VIBRATION  9
Equations of motion for Multi degree of freedom Systems - Solution of Eigen value problems – Normal coordinates and orthogonality Conditions. Modal Analysis

UNIT IV  ENERGY METHODS  9

UNIT V  APPROXIMATE METHODS  9
Approximate methods of evaluating the Eigen frequencies and eigen vectors by reduced, subspace, Lanczos, Power, Matrix condensation and QR methods.

TOTAL: 45 PERIODS

OUTCOMES:
• To study the effect of periodic and aperiodic forces on mechanical systems with matrix approach and also to get the natural characteristics of large sized problems using approximate methods.

TEXT BOOKS:

REFERENCES:

AL7014  THEOREY OF PLATES AND SHELLS  L T P C
OBJECTIVES:
• Gives exposure to formulation of governing equations, various types of analyses plate problems and the methods of solution.

UNIT I  CLASSICAL PLATE THEORY  8
Classical Plate Theory – Assumptions – Governing Equation – Boundary Conditions.

UNIT II  PLATES OF VARIOUS SHAPES  10
Navier’s Method of Solution for Simply Supported Rectangular Plates – Levy’s Method of Solution for Rectangular Plates under Different Boundary Conditions – Circular plates - Different edge conditions and loads.

UNIT III  FREE VIBRATION ANALYSIS  8
Stability and Free Vibration Analysis of Rectangular Plates with various end conditions.
UNIT IV  APPROXIMATE METHODS  10

UNIT V  SHELLS  9
Basic Concepts of Shell Type of Structures – Membrane and Bending Theories for Circular Cylindrical Shells.

OUTCOMES:
• Upon completion of the course, students will acquire knowledge on the analysis of plates and shells with different geometry under various types of loads.

REFERENCES

AL7015  TRANSONIC AERODYNAMICS  L T P C
3 0 0 3

OBJECTIVES:
• Students will be exposed to linearized theory and unsteady flow characteristics of transonic flow.
• Students will also learn transonic expansion procedures and design and operation of transonic wind tunnels

UNIT I  INTRODUCTION  6

UNIT II  LINEARIZED THEORY  9

UNIT III  TRANSONIC EXPANSION PROCEDURES  12

UNIT IV  TRANSONIC AIRFOIL THEORY  9
UNIT V  TRANSONIC WIND TUNNELS  9
Wind tunnels- Wide slots, Narrow slots- slotted walls - Slotted walls with perforated Cover Plates-
Transonic testing with wing flow Technique-Movable walls, Slotted walls, Perforated walls.

OUTCOMES:
- Upon completion of the course students will learn operational procedures of transonic wind
  tunnels and also transonic expansion procedures which will be useful in handling the flows
  containing both subsonic and supersonic regimes.

REFERENCES:

AL7016 WIND TURBINE ENGINEERING  L T P C  3 0 0 3

OBJECTIVES:
- To make students learn the aerodynamic design aspects and controlling methods of wind
  turbines and also environmental aspects of wind energy production estimating methods.

UNIT I  INTRODUCTION TO WINDENERGY  8
Background, Motivations, and Constraints, Historical perspective, Modern wind turbines,
Components and geometry, Power characteristics.

UNIT II  WIND CHARACTERISTICS AND RESOURCES  8
General characteristics of the wind resource, Atmospheric boundary layer characteristics, Wind
data analysis and resource estimation, Wind turbine energy production estimates using statistical
techniques

UNIT III  AERODYNAMICS OF WIND TURBINES  11
Overview, 1-D Momentum theory, Ideal horizontal axis wind turbine with wake rotation, Airfoils
and aerodynamic concepts -Momentum theory and blade element theory General rotor blade
shape performance prediction - Wind turbine rotor dynamics

UNIT IV  WIND TURBINE DESIGN& CONTROL  9
Brief design overview – Introduction -Wind turbine control systems -Typical grid-connected turbine
operation -Basic concepts of electric power- Power transformers -Electrical machines

UNIT V ENVIRONMENTAL AND SITE ASPECTS  9
Overview- Wind turbine sitting - Installation and operation- Wind farms- Overview of wind energy
economics - Electromagnetic interference - noise - Land use impacts - Safety-Concepts in wind
turbine development.

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course, students will learn about aerodynamics, design and control
  of wind turbines.

REFERENCES:
1. Emil Simiu & Robert H Scanlan, Wind effects on structures - fundamentals and applications to
3. N J Cook, Design Guides to wind loading of buildings structures Part I & II, Butterworths,
   London, 1985
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

Stoichiometry – absolute enthalpy- enthalpy of formation- enthalpy of combustion- laws of thermochemistry- pressure and temperature effect on enthalpy of formation, adiabatic flame temperature, chemical and equilibrium products of combustion.

UNIT II PHYSICS AND CHEMISTRY OF COMBUSTION


UNIT III PREMIXED AND DIFFUSED FLAMES


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


OUTCOMES:

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

REFERENCES

UNIT II  STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR  8
Low cycle and high cycle fatigue – Coffin-Manson’s relation – Transition life – Cyclic Strain hardening and softening – Analysis of load histories – Cycle counting techniques – Cumulative damage – Miner’s theory – other theories.

UNIT III  PHYSICAL ASPECTS OF FATIGUE  5

UNIT IV  FRACTURE MECHANICS  15

UNIT V  FATIGUE DESIGN AND TESTING  7
Safe life and fail safe design philosophies – Importance of Fracture Mechanics in aerospace structure – Application to composite materials and structures.

TOTAL: 45 PERIODS

OUTCOMES:
• Upon completion of the course, students will learn about fracture behaviour, fatigue design and testing of structures.

REFERENCES

AL7073  HIGH SPEED JET FLOWS  L T P C
30 0 3

OBJECTIVES:
• To make the students learn about various jet control methods, jet acoustics aspects and free shear layer flow theory pertaining to turbulent jets with high speed.

UNIT I  INTRODUCTION  9

UNIT II  COMPRESSIBLE FLOW THEORY  9
One-dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers – normal and oblique shock waves and calculation of flow and fluid properties across the shocks and expansion fans. Interaction of shocks with solid and fluid surface.

UNIT III  JET CONTROL  9
Types of jet control - single jet, multi jet, co-flow jet, parallel flow jet. Subsonic jets- Mathematical treatment of jet profiles- Theory of Turbulent jets- Mean velocity and mean temperature.
Turbulence characteristics of free jets - Mixing length- Experimental methods for studying jets and the Techniques used for analysis- Expansion levels of jets- Overexpanded, Correctly expanded, Underexpanded jets - Control of jets. Centre line decay, Mach number Profile, Iso-Mach (or iso-baric) contours, Shock cell structure in underexpanded and overexpanded jets, Mach discs.

UNIT IV BOUNDARY LAYER CONCEPT 9
Boundary Layer – displacement and momentum thickness- laminar and turbulent boundary layers over flat plates – velocity distribution in turbulent flows over smooth and rough boundaries-laminar sublayer. Shock-boundary layer interactions.

UNIT V JET ACOUSTICS 9

OUTCOMES:
• Upon completion of the course, students will learn the basics of nozzle flows, methods of jet control and acoustics of jet.

REFERENCES
UNIT IV  INTERPLANETARY TRAJECTORIES  8

UNIT V  BALLISTIC MISSILE TRAJECTORIES  9

OUTCOMES:
- Upon completion of the course student will be to perform basic trajectory computations pertaining to interplanetary flight, ballistic missile flight and will be able to learn computational methods for satellite injection and satellite perturbations.

TEXT BOOKS:

REFERENCES:

AL7075  THEORY OF BOUNDARY LAYERS  L T P C  3 0 0 3

OBJECTIVES
- To impart knowledge to students on growth of boundary layer and its effect on the aerodynamic design of airframe of flight vehicles and also to introduce them the solution methods for boundary layer problems.

UNIT I  FUNDAMENTAL EQUATIONS OF VISCOUS FLOW  8
Fundamental equations of viscous flow, Conservation of mass, Conservation of Momentum-Navier-Stokes equations, Energy equation, Mathematical character of basic equations, Dimensional parameters in viscous flow, Non-dimensionalising the basic equations and boundary conditions, vorticity considerations, creeping flow, boundary layer flow

UNIT II  SOLUTIONS OF VISCOUS FLOW EQUATIONS  10
Solutions of viscous flow equations, Couette flows, Hagen-Poisuelle flow, Flow between rotating concentric cylinders, Combined Couette-Poiseuille Flow between parallel plates, Creeping motion, Stokes solution for an immersed sphere, Development of boundary layer, Displacement thickness, momentum and energy thickness.

UNIT III  LAMINAR BOUNDARY LAYER  10
Laminar boundary layer equations, Flat plate Integral analysis of Karman – Integral analysis of energy equation – Laminar boundary layer equations – boundary layer over a curved body-Flow separation- similarity solutions, Blasius solution for flat-plate flow, 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 TURBULENT BOUNDARY LAYER
Turbulence-physical and mathematical description, 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, Eddy Viscosity, mixing length, Turbulence modelling

UNIT V BOUNDARY LAYER CONTROL
Boundary layer control in laminar flow-Methods of Boundary layer control: Motion of the solid wall-Acceleration of the boundary layer-Suction- Injection of different gas-Prevention of transition-Cooling of the wall-Boundary layer suction-Injection of a different gas.

TOTAL: 45 PERIODS

OUTCOMES:
• To make the student understand the importance of viscosity and boundary layer in fluid flow. To introduce the theory behind laminar and turbulent boundary layers.

TEXT BOOKS:

REFERENCES:

AS7151 COMPUTATIONAL HEAT TRANSFER

OBJECTIVES:
• To make the students learn to solve conductive, transient conductive, convective, radiative heat transfer problems using computational methods.

UNIT I INTRODUCTION
Finite Difference Method-Introduction-Taylor’s series expansion-Discretisation Methods Forward, backward and central differencing scheme for 1st 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 CONDUCTIVE HEAT TRANSFER

UNIT III TRANSIENT HEAT CONDUCTION

UNIT IV CONVECTIVE HEAT TRANSFER
UNIT V RADIATIVE HEAT TRANSFER


TOTAL: 45 PERIODS

OUTCOMES:

- Upon completion of the course, students will learn the concepts of computation applicable to heat transfer for practical applications

REFERENCES


AS7251 CHEMICAL ROCKET TECHNOLOGY L T P C

3 0 0 3

OBJECTIVES:

- To make student to acquire in depth knowledge in solid, liquid, hybrid rocket propulsion systems and also testing and performance of rocket propellants.

UNIT I SOLID ROCKET PROPULSION

Various subsystems of Solid rocket motor and their functions-Propellant grain design-erosive burning- L"instability –internal ballistics of solid rocket motor--types of ignites- igniter design considerations– special problems of solid rocket nozzles.

UNIT II LIQUID ROCKET PROPULSION


UNIT III HYBRID ROCKET PROPULSION


UNIT IV PROPELLANT TECHNOLOGY

Selection criteria for solid and liquid rocket propellants–calculation of adiabatic flame temperature– assessment of rocket performance–selections of propellant formulation–determination of propellant burnrate and factors influencing the burnrate–solid propellant processing
UNIT V  TESTING AND SAFETY

Static testing of rocket–instrumentation required–thrust Vs time–pressure Vs time diagrams–specific impulse calculation–safety procedures for testing of rockets and solid propellants–ignition delay testing.

OUTCOMES:
Upon completion of this course, students acquire knowledge in depth about chemical rocket propulsion.

REFERENCES

AS7253  HYPersonic Aerodynamics

OBJECTIVES:
- To make students learn the peculiar hypersonic speed flow characteristics pertaining to flight vehicles and the approximate solution methods for hypersonic flows. The objective is also to impart knowledge on hypersonic viscous interactions and their effect on aerodynamic heating.

UNIT I  BASICS OF HYPersonic Aerodynamics
Thin shock layers – entropy layers – low density and high density flows – hypersonic flight paths hypersonic flight similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.

UNIT II  SURFACE INCLINATION METHODS FOR HYPersonic INviscid FLOWS
Local surface inclination methods – modified Newtonian Law – Newtonian theory – tangent wedge or tangent cone and shock expansion methods – Calculation of surface flow properties.

UNIT III  APPROXIMATE METHODS FOR INviscid HYPersonic FLOWS

UNIT IV  VISCous HYPersonic FLOW THEORY
Navier–Stokes equations – boundary layer equations for hypersonic flow – hypersonic boundary layer – hypersonic boundary layer theory and non similar hypersonic boundary layers – hypersonic aerodynamic heating and entropy layers effects on aerodynamic heating – heat flux estimation.

UNIT V  VISCous INTERactions IN HYPersonic FLOWS
Strong and weak viscous interactions – hypersonic shockwaves and boundary layer interactions – Estimation of hypersonic boundary layer transition- Role of similarity parameter for laminar viscous interactions in hypersonic viscous flow.

TOTAL: 45 PERIODS

OUTCOMES:
- Upon completion of the course, students will learn basics of hypersonic flow, shock wave boundary layer interaction and hypersonic aerodynamic heating.
REFERENCES
2. John D. Anderson, Jr., Modern Compressible Flow with Historical perspective Hypersonic Series.
3. William H. Heiser and David T. Pratt, Hypersonic Air Breathing propulsion, AIAA Education Series