JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

(Established by an Act No.30 of 2008 of A.P. State Legislature)

Kukatpally, Hyderabad – 500 085, Andhra Pradesh (India)

M. TECH. (AEROSPACE ENGINEERING)

COURSE STRUCTURE AND SYLLABUS

I Year I Semester

Code	Group	Subject	L	P	Credits
		Mathematical Modeling	3	0	3
		Engineering Analysis of Flight Vehicles	3	0	3
		Continuum Mechanics	3	0	3
		Air Transportation Systems	3	0	3
	Elective –I	Fundamentals of Aerospace Engineering * Aerodynamics of Flight Vehicles Flight Vehicle Structures Air-breathing Propulsion Aircraft Systems	3	0	3
	Elective –II	Modeling and Simulation of Fluid Flows Computational Structural Analysis Flight Navigation and Surveillance Systems Airlines Operations and Scheduling Rotorcraft Aerodynamics	3	0	3
	Lab	Digital Simulation Lab-I	0	3	2
		Seminar	-	-	2
		Total Credits	18	3	22

I Year II Semester

Code	Group	Subject	L	P	Credits
		Aircraft Control and Simulation	3	0	3
		Space Transportation Systems	3	0	3
		Computational Approaches to Aerospace Vehicle Design	3	0	3
		Aerospace Sensors and Measurement Systems	3	0	3
	Elective –III	Aero-thermodynamics of Hypersonic Flight Dynamics and Control of Structures Missile Guidance Advanced Topics in Air Traffic Management Systems Spacecraft Dynamics and Control	3	0	3
	Elective –IV	Rocket and Spacecraft Propulsion Mechanics of Composite Materials Tactical Missile Design High Angle of Attack Aerodynamics Optimal Control	3	0	3
	Lab	Digital Simulation Lab-II	0	3	2
		Seminar	-	-	2
		Total Credits	18	3	22

II Year I Semester

Code	Group	Subject	L	P	Credits
		Comprehensive Viva	-	-	2
		Project Seminar	0	3	2
		Project work	-	-	18
		Total Credits	-	3	22

II Year II Semester

Code	Group	Subject	L	P	Credits
		Project work and Seminar	-	-	22
		Total Credits	-	-	22

*Fundamentals of Aerospace Engineering
(*Required to be taken by all students other than B.Tech Aeronautical/ Aerospace Engineering degree holders)*

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

MATHEMATICAL MODELING

Aim:

The student shall be introduced to advanced mathematic modeling concepts.

Outcome:

The student will be able mathematically describe the complex phenomena & can attempt solve using various numerical tools.

UNIT-I:

INTRODUCTION TO MODELING AND SINGULAR PERTURBATION METHODS

Definition of a model, Procedure of modeling: problem identification, model formulation, reduction, analysis, computation, model validation, Choosing the model, Singular Perturbations: Elementary boundary layer theory, Matched asymptotic expansions, Inner layers, Nonlinear oscillations

UNIT-II:

VARIATIONAL PRINCIPLES AND RANDOM SYSTEMS

Variational calculus: Euler's equation, Integrals and missing variables, Constraints and Lagrange multipliers, Variational problems: Optics-Fermat's principle, Analytical mechanics: Hamilton's principle, Symmetry: Noether's theorem, Rigid body motion, Random systems: Random variables, Stochastic processes, Monte Carlo method

UNIT-III:

FINITE DIFFERENCES: ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

ODE: Numerical approximations, Runge-Kutta methods, Beyond Runge-Kutta, PDE: Hyperbolic equations-waves, Parabolic equations-diffusion, Elliptic equations-boundary values

CELLULAR AUTOMATA AND LATTICE GASES

Lattice gases and fluids, Cellular automata and computing

UNIT- IV:

FUNCTION FITTING AND TRANSFORMS

Function fitting: Model estimation, Least squares, Linear least squares: Singular value decomposition, Non-linear least squares: Levenberg-Marquardt method, Estimation, Fisher information, and Cramer-Rao inequality, Transforms:Orthogonal transforms, Fourier transforms, Wavelets, Principal components

FUNCTION FITTING ARCHITECTURES

Polynomials: Pade approximants, Splines, Orthogonal functions, Radial basis functions, Over-fitting, Neural networks: Back propagation, Regularization

UNIT-V:

OPTIMIZATION AND SEARCH

Multidimensional search, Local minima, Simulated annealing, Genetic algorithms

FILTERING AND STATE ESTIMATION

Matched filters, Wiener filters, Kalman filters, Non-linearity and entrainment, Hidden Markov models

TEXT BOOK

1. *The Nature of Mathematical Modeling,* Neil Gershenfeld, Cambridge University Press, 2006, ISBN 0-521-57095-6

REFERENCE BOOKS

1. *Mathematical Models in the Applied Sciences,* A. C. Fowler, Cambridge University Press, 1997, ISBN 0-521-46140-5
2. *A First Course in Mathematical Modeling*, F. R. Giordano, M.D. Weir and W.P. Fox, 2003, Thomson, Brooks/Cole Publishers
3. *Applied Numerical Modeling for Engineers,* Donald De Cogan, Anne De Cogan, Oxford University Press, 1997

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

ENGINEERING ANALYSIS OF FLIGTHT VEHICLES

Aim:

The student shall be introduced to the advanced engineering analysis aspects of flight vehicles.

Outcome:

The student will be in a position to take up some specific tasks in flight vehicle engineering analysis.

UNIT-I:

THE MORPHOLOGY OF FLIGHT VEHICLES

Introduction, Key factors affecting vehicles configuration, Some representative flight vehicles.

UNIT-II:

EQUATIONS OF MOTION FOR RIGID FLIGHT VEHICLES

Definitions, Vector and Scalar realizations of Newton's second law, The tensor of inertia, Choice of vehicle axes, Operation of the vehicle relative to the ground; flight determination, Gravitational terms in the equations of motion, The state vector.

INTRODUCTION TO VEHICLE AERODYNAMICS

Aerodynamics contributions to X, Y and M, dimensionless coefficients defined, equations of perturbed longitudinal motion.

UNIT-III:

AIRCRAFT DYNAMICS

Equations of Motion of Aircraft including forces and moments of control surfaces, Dynamics of control surfaces

STATIC STABILITY, TRIM STATIC PERFORMANCE AND RELATED SUBJECTS

Impact of stability requirements on design and longitudinal control, Static performance

UNIT-IV:

DYNAMIC PERFORMANCE OF SPACECRAFT WITH RESPECT TO NON-ROTATING PLANETS

Introduction, Numerical integration of ordinary differential equations, Simplified treatment of boost from a non-rotating planet, An elementary look at staging, Equations of boost from a rotating planet.

UNIT-V:

DYNAMIC PERFORMANCE OF SPACECRAFT

Equations of Motion of Launch Vehicles with respect to a rotating planet, Motion of Spacecraft with respect to a rotating planet.

DYNAMIC PERFORMANCE-ATMOSPHERIC ENTRY

Equation of motion, Approximate analysis of gliding entry into a planetary atmosphere.

TEXT BOOK

1. *Engineering Analysis of Flight Vehicles*, Holt Ashley, Dover Publications, 1992

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

CONTINUUM MECHANICS

Aim:

The student shall be given the in depth understanding of continuum mechanics as applicable to aerospace structures.

Outcome:

The student will be solve complex problems in fluid structure interactions in continuum frame work.

UNIT I:

INTRODUCTION, VECTORS AND TENSORS

Background and Overview, Vector Algebra - Definition of a Vector, Scalar and Vector Products, Plane Area as a Vector, Components of a Vector, Summation Convention, Transformation Law for Different Bases; Theory of Matrices - Definition, Matrix Addition and Multiplication of a Matrix by a Scalar, Matrix Transpose and Symmetric Matrix, Matrix Multiplication, Inverse and Determinant of a Matrix; Vector Calculus - Derivative of a Scalar Function of a Vector, The del Operator, Divergence and Curl of a Vector, Cylindrical and Spherical Coordinate Systems, Gradient, Divergence and Curl Theorems; Tensors- Dyads and Polyads, Nonion Form of a Dyadic, Transformation of Components of a Dyadic, Tensor Calculus, Eigenvalues and Eigenvectors of Tensors

UNIT II:

KINEMATICS OF CONTINUA

Introduction, Description of Motion- Configurations of a Continuous Medium, Material Description, Spatial Description, Displacement Field; Analysis of Deformation- Deformation gradient tensors, Isochoric, Homogeneous and Inhomogeneous Deformations, Change of volume and surface; Strain Measures- Cauchy-Green deformation tensors, Green Strain tensor, Physical Interpretation of the Strain Components, Cauchy and Euler Strain Tensors, Principal Strains; Infinitesimal Strain Tensor and Rotation Tensor- Infinitesimal Strain Tensor, Physical Interpretation of Infinitesimal Strain Tensor Components, Infinitesimal Rotation Tensor, Infinitesimal Strains in Cylindrical and Spherical Coordinate Systems; Rate of Deformation and Vorticity Tensors- Definitions, Relationship between D and E, .Polar Decomposition Theorem, Compatibility Equations, Change of Observer- Material Frame Indifference.

UNIT III:

STRESS MEASURES

Introduction, Cauchy Stress Tensor and Cauchy's Formula, Transformation of Stress Components and Principal Stresses- Transformation of Stress Components, Principal Stresses and Principal Planes, Maximum Shear Stress. Other Stress Measures - Preliminary Comments, First Piola- Kirchhoff Stress Tensor, Second Piola- Kirchhoff Stress Tensor, Equations of Equilibrium.

CONSERVATION OF MASS, MOMENTA AND ENERGY

Introduction, Conservation of Mass - Preliminary Discussion, Material Time Derivative, Continuity Equation in Spatial Description, Continuity Equation in Material Description ,Reynolds Transport Theorem. Conservation of Momenta - Principle of Conservation of Linear Momentum, Equation of Motion in Cylindrical and Spherical Coordinates, Principle of Conservation of Angular Momentum, Thermodynamic Principles - Introduction, The First Law of Thermodynamics: Energy Equation, Special Cases of Energy Equation, Energy Equation for One-Dimensional Flows , The Second Law of Thermodynamics.

UNIT IV:

CONSTITUTIVE EQUATIONS

Introduction, Elastic Solids - Generalized Hooke's Law, Material Symmetry, Monoclinic Materials, Orthotropic Materials, Isotropic Materials, Transformation of Stress and Strain Components, Nonlinear Elastic Constitutive Relations, Constitutive Equations for Fluids - Ideal Fluids, Viscous Incompressible Fluids, Non-Newtonian Fluids, Heat Transfer - General Introduction, Fourier's Heat Conduction Law, Newton's Law of Cooling, Stefan-Boltzmann Law, Electromagnetics - Maxwell's Equation, Constitutive Relations.

LINEARIZED ELASTICITY

Governing Equations, The Navier Equations, The Beltrami-Michell Equations, Types of Boundary Value Problems and Superposition Principle. Clapeyron's theorem and Reciprocity Relations - Clapeyron's theorem, Betti's Reciprocity Relations, Maxwell's Reciprocity Relation, Solution Methods, Types of Solution Methods, Example: Rotating Thick Walled Cylinder; Two-Dimensional Problems, Airy Stress Function, End Effects: Saint-Venant's Principle, Torsion of Noncircular Cylinders. Principle of Minimum Total Potential Energy - Total Potential Energy Principle, Derivation of Navier's Equations, Castiglian's Theorem I . Hamilton's Principle-Hamilton's Principle for a Rigid Body, Hamilton's Principle for a Continuum

UNIT V:

FLUID MECHANICS AND HEAT TRANSFER

Governing Equations- Preliminary Comments, Summary of Equations, Viscous Incompressible Fluids, Heat Transfer; Fluid Mechanics Problems - Inviscid Fluid Statics, Parallel Flow (Navier-Stokes Equations), Problems with Negligible Convective Terms; Heat Transfer Problems- Heat Conduction in a Cooling Fin, Axisymmetric Heat Conduction in a Circular Cylinder, Two-Dimensional Heat Transfer, Coupled Fluid Flow and Heat Transfer

LINEAR VISCOELASTICITY

Preliminary Comments- Initial Value Problem, the Unit Impulse, and the Unit Step Function, The Laplace Transform Method, Spring and Dashpot Models - Creep Compliance and Relaxation Modulus, Maxwell Element , Kelvin-Voigt Element, Three-Element Models , Four-Element Models , Integral Constitutive Equations, Hereditary Integrals, Hereditary Integrals for Deviatoric Components, The Correspondence Principle, Elastic and Viscoelastic Analogies

TEXT BOOK

1. *An Introduction to Continuum Mechanics*, J.N. Reddy, Cambridge University Press, 2007

REFERENCE BOOKS

1. *Continuum Mechanics*, George. E. Mase, Schaum's Outline Series, McGraw-Hill Book Company, 1969
2. *Continuum Mechanics*, Ellis H. Dill, CRC Press, 2006
3. Continuum Mechanics for Engineers, Second Edition, George E. Mase, G.Thomas Mase CRC Press,1999
4. *Computational Continuum Mechanics*, Ahmed A. Shabana, Cambridge University Press, 2008
5. *Introduction to Computational Mechanics*, Fourth Edition, W. Michael Lai, David Rabin and Erhard krempl, .Elsevier Inc, 2010
6. *Introduction to the Mechanics of a Continuous Medium*, Lawrence E. Malvern, Prentice- Hall, 1969
7. *A First Course in Continuum Mechanics,* Y. C. Fung, Prentice Hall, 1994

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

AIR TRANSPORTATION SYSTEMS

Aim & Objectives:

The subject will introduce the air transportation systems in advanced level.

Outcome:

The student with acquire the operational knowledge of air transport.

UNIT – I:

THE AVIATION INDUSTRY

Introduction, history of aviation - evolution, development, growth, challenges. The aerospace industry, airline industry – structure and economic characteristics

UNIT – II:

AIR TRANSPORTATION SYSTEMS – OBJECTIVES, CONSTRAINTS

Air transportation systems – objectives, environment, operational constraints - statutory compliance with safety, security and environmental regulations, financial viability – demand, costs, efficiency and effectiveness, compatibility with operational infrastructure – aircraft, airports, facilities, equipment, crew and personnel, the atmosphere, air space..

STRATEGIES TO MEET OBJECTIVES

Analysis, understanding, forecasting, planning, marketing, management of resources. Adoption of improved technologies, optimal operational procedures, synthesis, implementation

UNIT –III:

THE SYSTEM ELEMENTS – AIRCRAFT

The system elements – the aircraft, airlines, airports, airspace. Aircraft - costs, compatibility with objectives, and operational infrastructure, direct and indirect operating costs, safety, security, efficiency and effectiveness.

AIRLINES – OBJECTIVES, PLANNING, OPERATIONS – PROCEDURES Route selection and development, fleet planning and acquisition, airline schedule development, fleet assignment, aircraft routing, gate assignment, flight operations - irregular operations, schedule recovery and robustness. Maintenance of aircraft and equipment. Airline operating costs and measure of productivity.

UNIT –IV:

AIRPORTS

Airports - demand, siting, runway characteristics, capacity, pavement strength, maneuvering area, aprons, passenger terminals, safety, security. Airport operations –. Airport demand, capacity and delays

UNIT – V:

AIRSPACE

Airspace management – Communication, navigation, surveillance systems - categories of airspace, sectors, separation minima, capacity, demand, delay. The ATC systems - evolution, equipment and operations. ICAO future air navigation systems

CHALLENGES OF THE FUTURE Coping with future changes. Critical issues and prospects for airline industry

TEXT BOOKS

1. *The Air Transport System*, Hirst, M.,Woodhead Publishing Ltd, (also AIAA), 2008, ISBN-13: 978 1 845693251.
2. *Airline Operations and Scheduling,* Bazargan, M.,Ashgate, 2004, ISBN – 075463616X.
3. *Air Transportation – A Management Perspective*, Wensveen,J.G., Ashgate, 2007, ISBN 978-0-7546-7171-8.
4. *Global Airline Industry*, Belobaba, P. et al., AIAA,2009.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

FUNDAMENTALS OF AEROSPACE ENGINEERING
(ELECTIVE-I)

Aim: To impart fundamental and advanced aspects of aerospace engineering to non B. Tech aeronautical engineering students.

Outcome: The non B. Tech aeronautical engineering students will gain insights to various aspects of aircraft structures flight systems and flight mechanics.

UNIT-I:

INTRODUCTION TO AERONAUTICS AND ASTRONAUTICS: Historical Perspective of Aeronautics and Astronautics, Anatomy of the Airplane, Anatomy of a Space Vehicle, Aerodynamic forces, Parameters affecting aerodynamic forces: Dimensional analysis; Theory and experiment: wind tunnels, Atmosphere: Properties of U.S. standard atmosphere, Definitions of altitude,

UNIT-II:

ONE DIMENSIONAL FLOWS IN INCOMPRESSIBLE AND COMPRESSIBLE FLUIDS: Continuity equation, Bernoulli's equation, Application of Bernoulli's equation: Airspeed indicators and wind tunnels, One-dimensional compressible flow concepts, Speed of sound, Compressible flow equations in a variable-area stream tube, Application to airspeed measurement, Applications to channels and wind tunnels

TWO-DIMENSIONAL FLOW AND FINITE WING: Limitations of one-dimensional flow equations, Theory of lift: circulation, Airfoil pressure distribution, Helmholtz vortex theorems, Simulating the wing with a vortex line, Downwash, Elliptic lift distribution, Lift and drag: momentum and energy, Slope of finite wing lift curve, Verification of Prandtl wing theory, Additional effects of wing vortices, Search for reduced induced drag

UNIT-III:

VISCOUS EFFECTS, TOTAL DRAG DETERMINATION AND HYPERSONIC FLOWS: Boundary layer, Boundary layer on bluff bodies, Creation of circulation, Laminar and turbulent boundary layers: skin friction, Nature of Reynolds number, Effect of turbulent boundary layer on separation; Parasite drag, Drag due to lift, Importance of aspect ratio; Prediction of drag divergence Mach number, Sweptback wings, Total drag, Supersonic flow: shock waves and Mach waves, Supersonic wing lift and drag, Area rule, Supersonic aircraft, Hypersonic flows: Temperature effects, Newtonian theory

AIRFOILS, WINGS AND HIGHLIFT SYSTEMS: Early airfoil development, Modern airfoils, Supersonic airfoils, Airfoil pitching moments, Effects of sweepback on lift, airfoil characteristics, Airfoil selection and wing design; Airfoil maximum lift coefficient, Leading and trailing edge devices, Effect of sweepback, Deep stall, Effect of Reynolds number, Propulsive lift

UNIT-IV:

AIRPLANE PERFORMANCE, STABILITY AND CONTROL: Level flight performance, Climb performance, Range, Endurance, Energy-state approach to airplane performance, Takeoff performance, Landing performance; Static longitudinal stability, Dynamic longitudinal stability, Dynamic lateral stability, Control and Maneuverability: turning performance, Control systems, Active controls

UNIT-V:

AEROSPACE PROPULSION AND AIRCRAFT STRUCTURES: Aerospace Propulsion: Piston engines, Gas turbines, Speed limitations of gas turbines: ramjets, Propellers, Overall propulsion efficiency, Rocket engines, Rocket motor performance, Propulsion-airframe integration; Aircraft structures: Importance of structural weight and integrity, Development of aircraft structures, Importance of fatigue, Materials, Loads, Weight estimation

ROCKET TRAJECTORIES, ORBITS AND REENTRY: Rocket trajectories, Multistage rockets, Escape velocity, Circular orbital or satellite velocity, Elliptical orbits, Orbital maneuvers, Atmospheric entry: ballistic entry and lifting entry, Entry heating

TEXT BOOK

1. *Fundamentals of Flight*, Richard S. Shevell, Pearson Education Publication, ISBN 81-297-0514-1, 1989

REFERENCE BOOK

1. *Introduction to Flight,* John D. Anderson, Jr., Tata McGraw-Hill Publishing Company, Fifth Edition, Fifth Edition, 2007, ISBN 13: 978-0-07-066082-3

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

I Year M.Tech., AE- I Semester

AERODYNAMICS OF FLIGHT VEHICLES
(ELECTIVE-I)

Aim:
The student shall be taught advanced concepts in aero dynamics of flight vehicles.

Outcome:
The student will able tackle complex aero dynamics problems.

UNIT-I:
AERODYNAMIC CHARACTERISTICS OF AIRFOILS: Vortex sheet, Vortex sheet in thin-airfoil theory, Planar wing, Properties of symmetrical airfoil, Properties of cambered airfoil, Flapped airfoil, Numerical Solution of thin airfoil problem, Airfoil of arbitrary thickness and camber

UNIT-II:
THE FINITE WING: Flow fields around finite wings, Downwash and induced drag, Fundamental equations of finite-wing theory, Elliptical lift distribution, Arbitrary circulation distribution, Twisted wing: Basic and Additional lift, Approximate calculation of additional lift, Winglets, Stability and trim of wings, Higher approximations, The complete airplane, Interference effects,
AIRFOILS IN COMPRESSIBLE FLOWS: Boundary conditions, Airfoils in subsonic flow: Prandtl-Glauert transformation, Critical Mach number, Airfoils in transonic flow, Airfoils in supersonic flow

UNIT-III:
WINGS AND WING-BODY COMBINATIONS IN COMPRESSIBLE FLOW: Wings and bodies in compressible flows: Prandtl-Glauert-Goethert transformation, Influence of sweepback, Design rules for wing-fuselage combinations
LAMINAR BOUNDARY LAYER IN COMPRESSIBLE FLOW: Conservation of energy in the boundary layer, Rotation and entropy gradient in the boundary layer, Similarity considerations for compressible boundary layers, Solution of energy equation for Prandtl number unity, Temperature recovery factor, Heat transfer versus skin friction, Velocity and temperature profiles and skin friction, Effects of pressure gradient

UNIT-IV:
FLOW INSTABILITIES AND TRANSITION FROM LAMINAR TO TURBULENT FLOW: Gross effects, Reynolds experiment, Tollmien-Schlichting instability and transition, Natural laminar flow and laminar flow control, Stability of vortex sheets, Transition phenomenon, Methods for experimentally detecting transition, Flow around spheres and circular cylinders

UNIT-V:
TURBULENT FLOWS: Description of turbulent field, Statistical properties, Conservation equations, Laminar sub-layer, Fully developed flows in tubes and channels, Constant-pressure turbulent boundary layer, Turbulent drag reduction, Effects of pressur gradient, Stratford criterion for turbulent separation, Effects of compressibility on skin friction, Reynolds analogy: Heat transfer and temperature recovery factor, Free turbulent shear flows
AIRFOIL DESIGN, MULTIPLE SURFACES, VORTEX LIFT, SECONDARY FLOWS, VISCOUS EFFECTS: Airfoil design for high $C_{l\,max}$, Multiple lifting surfaces, Circulation control, Streamwise vorticity, Secondary flows, Vortex lift strakes, Flow about three-dimensional bodies, Unsteady lift

TEXT BOOK

1. *Foundations of Aerodynamics: Bases of Aerodynamic Design*, Arnold M. Kuethe and Chuen- Yen Chow, John Wiley & Sons, Inc., Fifth Edition, 1997, ISBN: 978-0-471-12919-6

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

FLIGHT VEHICLE STRUCTURES
(ELECTIVE-I)

Aim:
The student will be exposed to advanced topics in flight vehicle structural analysis.

Outcome:
The student shall be able to solve flight vehicle structural problems can participate structural design.

UNIT-I:
STRUCTURAL COMPONENTS AND LOADS OF AIRCRAFT
Loads on Structural components, Function of structural components, Fabrication of structural components, Connections; Airworthiness: Factors of Safety- flight envelope, Load factor determination, Airframe loads: Aircraft inertia loads, Symmetric maneuver loads, Normal accelerations associated with various types of maneuvers, Gust loads

UNIT-II:
SHEAR FLOW AND SHEAR CENTER IN OPEN AND CLOSED THIN WALL SECTIONS
Open Sections:Shear center and elastic axis, Concept of shear flow, Beams with one axis of symmetry; Closed Sections: Bradt-Batho formula, Single and multi-cell closed box structures, Semi monocoque and mono cocque structures, Shear flow in single and multi cell monocoque and semimonocoque box beams subject to torsion

UNIT-III:
THIN PLATE THEORY
Bending of thin plates: Pure bending of thin plates, Plates subjected to bending and twisting, Plates subject to distributed transverse load, Combined bending and in-plane loading of a thin rectangular plate, Bending of thin plates having a small initial curvature, Energy method for bending of thin plates
STRUCTURAL INSTABILITY IN THIN PLATES
Buckling of thin plates, Inelastic buckling of plates, Experimental determination of critical loads for a flat plate, Local instability, Instability of stiffened panels, Failure stress in plates and stiffened panels, Tension field beams

UNIT-IV:
BENDING, SHEAR AND TORSION OF THIN-WALLED BEAMS-I
Bending and Open Thin-Walled Beams: Symmetrical bending, Unsymmetrical bending, Deflections due to bending, Calculation of section properties, Applicability of bending theory, Temperature effects
BENDING, SHEAR AND TORSION OF THIN-WALLED BEAMS-II
Shear of Beams: General stress, strain and displacement relationships for open and single cell closed section thin-walled beams, Shear of open and closed section beams; Torsion of Beams: Torsion of closed and open section beams; Combined Open and Closed Section Beams: Bending, Shear, Torsion

UNIT-V:
STRESS ANALYSIS OF AIRCRAFT COMPONENTS
Wing spars, Fuselages, Wings, Fuselage frames and wing ribs, Laminated composite structures
SMART MATERIALS AND ADAPTIVE STRUCTURES
Smart Materials Technologies and Control Applications: Control requirements, Smart Materials- Piezoelectric elements, Electrostrictive elements, Magentostrictive transducers, Electrorheological fluids, Shape memory alloys, Fiber optic sensors, Applications of smart materials, Adaptive Structures: Adaptive aerospace structures-Structural Health Monitoring (SHM), Shape control and active flow, Damping of vibration and noise, Smart skins, Systems

TEXT BOOK

1. *Aircraft Structures for Engineering Students* , Fourth Edition, T. H. G. Megson, Butterworth-Heinemann, Elsevier Ltd, 2007

REFERENCES

1. *Mechanics of Aircraft Structures*, Second Edition, C. T. Sun**,** John Wiley & Sons, 2006
2. *Theory and Analysis of Flight Structures,* Robert M. Rivello, McGraw-Hill, 1969
3. *Airplane Structural Analysis and Design,* Earnest E. Sechler, Lois G. Dunn, Dover Publications, 1963
4. *Mechanics of Elastic Structures,* J. T. Oden and E. A. Ripperger, McGraw-Hill, 1981
5. *Smart Material Structures: Modeling, Estimation and Control,* H. T. Banks, R. C. Smith, Y. Wang, John Wiley & Sons, 1996
6. *Adaptive Structures: Engineering Applications,* David Wagg, Ian Bond, Paul Weaver and Michael Friswell (editors), John Wiley & Sons, 2007

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

AIR-BREATHING PROPULSION
(ELECTIVE-I)

Aim:
The student will be introduced to advanced topics in air breathing propulsion systems.

Outcome:
The student will be able to trouble shoot the problems in air breathing propulsion systems.

UNIT-I:

FUNDAMENTALS OF JET PROPULSION

Principles of Air-breathing Propulsion, Basic Thermodynamics, Propulsion Cycles, Classification of Engines, Ideal and Real Cycle Analysis - Turbojet and Turbofan, Effects of Altitude, Mach number, Aircraft Performance and Engine Performance analysis, Aircraft Engine Design, Thrust Augmentation methods, Jet Engine Noise and Methods of Noise Reduction.

UNIT-II:

INLETS AND NOZZLES

Subsonic and Supersonic Inlets, Combined Area Changes and Friction, Supersonic Inlet Design Considerations, Starting an inlet, Additive Drag, Performance Map, Nozzles- Non-ideal equations for Various Nozzles, Converging-Diverging Nozzle, Variable Nozzle and Effects of Pressure Ratios on Engine Performance, Performance Maps, Thrust Reversers, Thrust Vectoring.

COMBUSTION CHAMBER

Combustion Process, Chemical Kinetics, Fuel Types and Properties, Variation in Gas Properties, Factors affecting Combustion Process, Types of Combustion Chambers, Flame Stabilization, Ignition and Engine Starting, Adiabatic Flame Temperature, Pressure Losses, Design and Optimization, Performance Maps.

UNIT-III:

COMPRESSORS AND TURBINES

Types of Compressors, Euler’s Turbo-Machinery Equations, Axial Compressors-Geometry of Compressors, Velocity Polygons and Triangles, Single-Stage Energy Analysis, Variable Stators, Radial Equilibrium and Streamline Analysis Method; Centrifugal Compressors- Geometry, Velocity Polygons, Impeller Design, Performance Maps; Axial Flow Turbines- Geometry, Single-Stage Energy analysis, Velocity Triangles, Performance Maps, Thermal Limits of Blades and Vanes, Numerical problems and Performance Analysis.

RAMJETS

Basics of Ramjets, Combustors for liquid fuel ramjet engines, Combustion Instability and its Suppression, Solid fuel Ramjet Engines, Testing of Ramjets, Ram-rockets- Performance analysis, Ducted and Shrouded types, Air-augmented rockets, Integrated ramjet-rocket systems, Nozzle-less solid propellant rockets and Integrated Ramjet-rocket boosters, Dump combustors and associated combustion problems, Computational fluid dynamics techniques in the design and development of combustors.

UNIT-IV:

HYPERSONIC AIR-BREATHING PROPULSION

Hypersonic Air-breathing Propulsion, SCRAM jet engines-Methods of Analysis, Hypersonic Intakes, Supersonic Combustors, Engine Cooling and Materials Problem, CFD Applications, Liquid Air-cycle Engines, Space Plane Applications, Experimental and Testing Facilities, The Shock Tunnel.

UNIT-V:

DESIGN OF GAS TURBINE ENGINE

Aircraft Mission Analysis, Engine Selection- Performance and Parametric Analysis, Sizing the Engine, Major Considerations in Engine Component Design - Rotating Turbo-machinery, Combustion Systems, Inlets and Exhaust Nozzles

SYSTEM MATCHING AND ANALYSIS

Matching of Gas Turbine Components, Cycle Analysis of one and two spool engines, Gas Generator, Component Modeling, Solution of Matching Problem, Dynamic or Transient behavior, Matching of Engine and Aircraft, Use of Matching and Cycle analysis in Second stage design

TEXT BOOKS

1. Fundamentals of Jet Propulsion with applications, Ronald D. Flack, Cambridge University Press, 1st Edition, 2005.
2. Elements of Propulsion: Gas turbines and Rockets, Jack D. Mattingly, AIAA Education series, 2nd Edition, 2006
3. Aircraft Engine Design, Jack D. Mattingly, AIAA Education Series, 2nd Edition, 2008.
4. Hypersonic Airbreathing Propulsion, William H. Heiser, David T. Pratt, AIAA Education Series, 1st Edition, 1994
5. Gas Turbine theory, Cohen H., Rogers G.F.C, Saravanamutto H., Longman Publication, 4th Edition, 2003

Reference Books:

1. Gas Tables, Third edition E. RathaKrishnan, University press.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

AIRCRAFT SYSTEMS
(ELECTIVE-I)

Aim:
At masters level the student will be mandated to study to advanced topics in aircraft systems.

Outcome:
The student will be able to trouble shoot the issues arising in aircraft systems.

UNIT – I:
AIRCRAFT SYSTEMS
System - definition, examples, attributes – process, input, output, feedback, external influence. Systems engineering, application to engineering systems. Aircraft systems – principal components – airframe systems, vehicle (utility) systems, avionics systems, mission systems. Subsystems – purpose, description, safety aspects, integration, design drivers. The product life cycle – stages – the engineering processes.

UNIT – II:
AIRCRAFT HYDRAULIC SYSTEMS
Hydraulic system services, the hydraulic circuit, actuation, the hydraulic fluid, hydraulic piping, hydraulic pump, fluid conditioning, the reservoir, emergency power sources. Aircraft applications, examples of B Ae, Airbus, Boeing implementations. The landing gear system for retraction, steering, braking and anti-skid.

ELECTRICAL SYSTEMS
Aircraft electrical system characteristics, power (AC and DC) generation, Power generation control, voltage regulation, parallel operation, supervisory and protection functions. Modern electrical power generation types, Electrical power quality. Primary power distribution, power conversion and energy storage. Secondary power distribution, power switching, load protection. Electrical loads, motors and actuators, lighting, heating, subsystem controllers, ground power. Emergency power generation. Typical civil transport aircraft electrical systems examples. Electrical load management system. Aircraft electrical wiring.

UNIT – III:
ENGINE CONTROL AND FUEL SYSTEMS
The engine control problem, control system parameters, example systems, design criteria. Engine starting, air flow, fuel flow & ignition control, engine rotation, throttle levers, engine indications. Integrated flight and propulsion control.

Characteristics of aircraft fuel systems, fuel system components – fuel transfer pumps, fuel booster pumps, fuel transfer valves, non-return valves. Fuel quantity measurement systems. Fuel system operation modes - fuel pressurization, engine feed, fuel transfer, use of fuel as heat sink, external fuel tanks, fuel jettison, in-flight refueling. Integrated civil aircraft fuel systems.

PNEUMATIC SYSTEMS AND ENVIRONMENTAL CONTROL SYSTEMS.
Use of pneumatic power in aircraft, Sources of pneumatic power, the engine bleed air, engine bleed air control. Users of pneumatic power, wing and engine anti-ice, engine start, thrust reversers, hydraulic system, pitot-static systems.

The need for controlled environment in aircraft. Sources of heat. Environmental control system design, ram air cooling, fuel cooling, engine bleed, bleed flow and temperature control. Refrigeration systems, air cycle and vapour cycle systems, turbo fan, boot strap, reversed boot strap systems. Humidity control. Air distribution systems. Cabin pressurisation, g tolerance, rain dispersal, anti-misting and demisting. In-flight entertainment systems

UNIT – IV:

FLIGHT CONTROL SYSTEMS

Principles of flight control, flight control surfaces, control surface actuation, flight control linkage systems, trim and feel. Power control, mechanical, direct drive, electromechanical, electro-hydrostatic actuation, multiple redundancy. The fly by wire system. Airbus and Boeing implementations, Inter-relationship of flight control, guidance and vehicle management systems.

Advanced systems - integrated flight and propulsion control, Vehicle management systems. All-electric aircraft concept, more-electric aircraft power generation concepts. Impact of stealth design- examples

SYSTEMS SAFETY, DESIGN AND DEVELOPMENT

Safety considerations – function, performance, integrity, reliability, dispatch availability, Economy considerations – maintainability, product support. Failure severity categorization, design assurance levels. Integration of aircraft systems

Systems design, specifications and requirement, regulations. Design guidelines and certification techniques. Safety assessment processes - functional hazard analysis, preliminary systems safety analysis, systems safety analysis, common cause analysis. Requirements capture. Fault tree analysis, failure modes and effects analysis, component reliability, dispatch reliability, Markov analysis.

UNIT – V:

SYSTEMS ARCHITECTURE, INTEGRATION

Architectural representation of systems, merits, definitions, types, architecture modeling and trade-off. Systems integration, definitions, levels of integration, examples, management o f systems integration. Aircraft system example

Verification of system requirements, tools - modeling, simulation, test rigs and prototypes, Modeling techniques - types of models and simulations. Test rigs and prototypes. Declaring verification.

Need for interoperability of evolving systems. Forward compatibility and backward compatibility, Factors affecting compatibility. System configurations. representation. configuration control – need, the process.

TEXT BOOKS

1. *Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration*, Moir, I. and Seabridge, A., AIAA Education Series, AIAA, 2001, ISBN: 1-56347506-5
2. *Design and Development of Aircraft Systems – An Introduction*, Moir, I., and Seabridge, A., AIAA Education Series, AIAA, 2004, ISBN: 1-56347-722-X.
3. *Civil Avionics Systems*, Moir, I. and Seabridge, A., AIAA Education Series, AIAA, 2002, ISBN 1-56347589-8

REFERENCES

1. *Ground Studies for Pilots: Flight Instruments and Automatic Flight Control Systems*, Harris, D., sixth edition, Blackwell Science, 2004, ISBN 0-632-05951-6.
2. *Aircraft Electrical Systems*, Pallet, E. H. J., Indian Edition, The English Book Store, New Delhi, 1993, ISBN81-70002-059-X
3. *Pneumatic and Hydraulic Systems*, Bolton, W.,Butterworth Heinemann.
4. *Aircraft Instruments & Integrated Systems*, Pallett, E.H.J., Longman Scientific & Technical, 1996.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

MODELLING AND SIMULATION OF FLUID FLOWS
(Elective-II)

Aim:
The student is exposed to advanced topics in fluid flow to tackle engineering problems in aircraft fluid systems.

Outcome:
The student can resolve fluid flow issues in aircraft systems in mathematically.

UNIT-I:
BASIC EQUATIONS OF FLUID DYNAMICS AND DYNAMICAL LEVELS OF APPROXIMATION
General form of a conservation law, Mass conservation equation, Momentum conservation law or equation of motion, Energy conservation equation; Navier–Stokes equations, Approximations of turbulent flows, Thin shear layer approximation, Parabolized Navier–Stokes equations, Boundary layer approximation, Distributed loss model, Inviscid flow model: Euler equations, Potential flow model.

UNIT II:
MATHEMATICAL NATURE OF THE FLOW EQUATIONS AND THEIR BOUNDARY CONDITIONS
Simplified models of a convection–diffusion equation, Definition of the mathematical properties of a system of PDEs, Hyperbolic and parabolic equations: characteristic surfaces and domain of dependence, Time-dependent and conservation form of the PDEs, Initial and boundary conditions

UNIT III:
DISCRETIZATION TECHNIQUES
Finite Difference Method for Structured Grids: Basics of finite difference methods, Multidimensional finite difference formulas, Finite difference formulas on non-uniform grids, General method for finite difference formulae, Implicit finite difference formulae; Finite Volume Method: Conservative discretization, Basis of finite volume method, Practical implementation of finite volume method; Introduction to Finite Element Method: Finite element definition of interpolation functions, Finite element definition of the equation discretization: integral formulation, Method of weighted residuals or weak formulation, Galerkin method, Finite element Galerkin method for a conservation law; Structured and Unstructured Grid Properties: Structured grids, Unstructured grids, Surface and volume estimations, Grid quality and best practice guidelines

UNIT IV:
ANALYSIS OF NUMERICAL SCHEMES
Consistency, stability and error analysis of numerical schemes: Basic concepts and definitions, Von Neumann method for stability analysis, New Leapfrog, Lax-Fredrichs and Lax-Wendroff schemes for the linear convection equation, Spectral analysis of numerical errors; General Properties and High Resolution Numerical Schemes: General formulation of numerical schemes, Generation of new schemes with prescribed order of accuracy, Monotonicity of numerical schemes, Finite volume formulation of schemes and limiters
TIME INTEGRATION METHODS FOR SPACE DISCRETIZED EQUATIONS Analysis of space-discretized systems, Analysis of time integration schemes, Selection of time integration methods, Implicit schemes for multidimensional problems: Approximate factorization methods

UNIT -V
ITERATIVE METHODS FOR RESOLUTION OF ALGEBRAIC SYSTEMS
Basic iterative methods, Overrelaxation methods, Preconditioning techniques, Nonlinear problems, Multigrid method.
NUMERICAL SIMULATION OF INVISCID FLOWS Euler equations, Potential flow model, Numerical solutions for the potential equation, Finite volume discretization of the Euler equations, Numerical solutions for the Euler equations

NUMERICAL SOLUTIONS OF VISCOUS LAMINAR FLOWS Navier-Stokes Equations for laminar flows, Density based methods for viscous flows, Numerical solutions with the density-based method, Pressure correction method, Numerical solutions with pressure correction method.

TEXT BOOK

1. *Numerical Computation of Internal and External Flows*, Second Edition, Charles Hirsch, Elsevier Publication, 2007

REFERENCES

1. *Computational Fluid Dynamics: The Basics with Applications*, John David Anderson, McGraw Hill, 1995
2. Computational Fluid Mechanics and Heat Transfer, 2nd Edition, John C. Tannehill, Dale A. Anderson, Richard H. Pletcher, Taylor & Francis, 1997.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

COMPUTATIONAL STRUCTURAL ANALYSIS
(Elective-II)

Aim:
The student shall be thought FEM, FDM, BEM, CFD based aircraft structural analysis.

Outcome:
The student shall be able to carry out mathematical analysis aircraft structures.

UNIT I:
NTRODUCTION, FINITE ELEMENT DISCRETIZATION OF PHYSICAL SYSTEMS : Areas of Analysis, Methods of Analysis, Computer Software, Brief History of the Finite Element Method, Finite Element Solutions, Application of the Galerkin Method

UNIT- II:
STRUCTURAL MECHANICS-BASIC THEORY, STRUCTURAL MECHANICS-FINITE ELEMENTS : Modeling of Material Behavior, Finite Element Formulation Based on the Stationary Functional Method,. One-Dimensional Line Elements, Two-Dimensional Plane Elements, Three-Dimensional Solid Elements, Isoparametric Quadrilateral and Hexahedron Elements, Torsion of Prismatic Shafts, Plate Bending Elements, Shell Elements.
SPINNING STRUCTURES, DYNAMIC ELEMENT METHOD: Derivation of Equation of Motion, Derivation of Nodal Centrifugal Forces, Derivation of Element Matrices; Bar Element, Beam Element, Rectangular Pre-stressed Membrane Element, Plane Triangular Element, Shell Element.

UNIT -III:
GENERATION OF SYSTEM MATRICES, SOLUTION OF SYSTEM EQUATIONS: Coordinate Systems and Transformations, Matrix Assembly, Imposition of Deflection Boundary Conditions, Matrix Bandwidth Minimization, Sparse Matrix Storage Schemes; Formulation and Solution of System Equation, Sparse Cholesky Factorization.

UNIT -IV:
EIGENVALUE PROBLEMS, DYNAMIC RESPONSE OF ELASTIC STRUCTURES : Free Vibration Analysis of Undamped Nonspinning Structures, Free Vibration Analysis of Spinning Structures, Quadratic Matrix Eigenvalue Problem for Free Vibration Analysis, Structural Stability Problems, Vibration of Prestressed Structures, Vibration of Damped Structural Systems, Solution of Damped Free Vibration Problem; Method of Modal Superposition, Direct Integration Methods, Frequency Response Method; Response to Random Excitation.

UNIT V:
NONLINEAR ANALYSIS, STRESS COMPUTATIONS AND OPTIMIZATION: Geometric Nonlinearity, Material Nonlinearity, Numerical Examples; Line Elements, Triangular Shell Elements, Solid Elements, Optimization, Examples of Applications of Optimization
HEAT TRANSFER ANALYSIS OF SOLIDS, COMPUTATIONAL LINEAR AEROELASTICITY AND AEROSERVOELASTICITY : Heat Conduction, Solution of System Equations, Numerical Examples, Coupled Heat Transfer and Structural Analysis.; Formulation of Numerical Procedure, Numerical Example
CFD-BASED AEROELASTICITY AND AEROSERVOELASTICITY : Computational Fluid Dynamics, Time-Marched Aeroe1astic and Aeroservoe1astic Analysis,
ARMA Model in Aeroelastic and Aeroservoelastic Analysis, Numerical Examples

TEXT BOOK

1. *Finite Element Multidisciplinary Analysis*, K.K.Gupta and J.L.Meek, Second Edition, AIAA, Education Series, 2003.

REFERENCE BOOK

1. *Finite Element Analysis – Theory and Application with ANSYS*, Saeed Moaveni, Second Edition, Prentice Hall, 2003

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

FLIGHT NAVIGATION AND SURVEILLANCE SYSTEMS
(ELECTIVE-II)

Aim: The student will be taught foundation in flight navigation and surveillance systems.

Outcome: The student will gain insights into real time functioning of aircraft navigation and surveillance systems.

UNIT-I:

ROLE OF NAVIGATION IN FLIGHT VEHICLE MISSION - NAVIGATION EQUATIONS: Introduction: Definitions of navigation and surveillance, Guidance versus navigation, Categories of navigation, Civil and military aircraft, Phases of flight, Design trade-offs, Evolution of avionics, Human navigator; Navigation Equations: Geometry of the Earth, Coordinate frames, Dead-reckoning computations, Positioning, Terrain-matching navigation, Course computation, Navigation errors, Digital charts, Software development

UNIT-II:

TERRESTRIAL-RADIO-NAVIGATION SYSTEMS: General principles, System design considerations, Point source systems, Hyperbolic systems

SATELLITE RADIO NAVIGATION: System configuration, Basics of satellite radio navigation, Orbital mechanics and clock characteristics, Atmospheric effects on satellite signals, NAVSTAR Global Positioning System, Global Orbiting Navigation Satellite System(GLONASS), GNSS integrity and availability

UNIT-III:

INERTIAL NAVIGATION: Inertial navigation system, Instruments, Platforms, Mechanization equations, Error analysis, Alignment, Fundamental limits

AIR-DATA SYSTEMS, ATTITUDE AND HEADING REFERENCES: Air-Data Systems: Air-data measurements, Air-data equations, Air-data systems, Specialty designs, Calibration and system test; Attitude and Heading References: Basic instruments, Vertical references, Heading references, Initial alignment of heading references

UNIT-IV:

DOPPLER AND ALTIMETER RADARS, LANDING SYSTEMSL: Doppler Radars: Functions and applications, Doppler radar principles and design approaches, Signal characteristics, Doppler radar errors, Equipment configurations, Radar Altimeters: Functions and applications, General principles, Pulsed radar altimeters, FM-CW radar altimeter, Phase-coded pulsed radar altimeters; Landing Systems: Low-visibility operations, Mechanics of landing, Automatic landing systems, Instrument landing systems, Microwave-landing system, Satellite landing systems, Carrier landing systems,

UNIT-V:

MULTISENSOR INTEGRATED NAVIGATION SYSTEMS: Inertial system characteristics, Integrated stellar-inertial systems, Integrated Doppler- inertial systems, Airspeed-damped inertial system, Integrated stellar-inertial-doppler system, Position update of an inertial system, Noninertial GPS multisensor navigation systems, Filtering of measurements, Kalman filter basics, Open-loop and closed loop Kalman filter mechanizations, GPS-INS mechanization, Practical considerations, Federated system architecture

AIR TRAFFIC MANAGEMENT: Services provided to aircraft carriers, Government responsibilities, Flight rules and airspace organization, Airways and procedures, Phases of flight, Subsystems, Facilities and operations, System capacity, Airborne Collision Avoidance Systems

TEXT BOOKS

1. *Avionics Navigation Systems,* Second Edition, Myron Kayton and Walter R.Freid, John Wiley & Sons, Inc, 1997, ISBN 0-471-54795-6
2. *Civil Avionics Systems,* Moir, I and Seabridge, A, AIAA Education Series, AIAA, 2002, ISBN 1-56347589-8

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

AIRLINES OPERATIONS AND SCHEDULING
(ELECTIVE-II)

Aim:
The student shall be taught advanced and latest topics in airlines operations scheduling.

Outcome:
The student shall be able to trouble shoot operational issues in airlines operations.

UNIT – I:
NEWORK FLOWS AND INTEGER PROGRAMMING MODELS : Complexity of airline planning, operations and dispatch - need for optimization – role of operations research and simulation. Networks, definitions, network flow models – shortest path problem, minimum cost flow problem, maximum flow problem, multi-commodity problem. Integer programming models – partitioning problems, travelling salesman problem – mathematical formulation – decision variables, objective function, constrains, methods of solution. Solution by simulation.

UNIT – II:
FLIGHT SCHEDULING : Significance of flight scheduling. The route system of the airlines – point-to-point flights, hub-and-spoke flights. Schedule construction- operational feasibility, economic viability. Route development and flight scheduling process – load factor and frequency – case study
FLEET ASSIGNMENT : Purpose of fleet assignment. Fleet types, fleet diversity, fleet availability – performance measures, Formulation of the fleet assignment problem – decision variables, objective function, constraints, solution. Scenario analysis. Fleet assignment models**.**

UNIT – III:
AIRCRAFT ROUTING : Goal of aircraft routing –maintenance requirements, other constraints. Routing cycles, routing generators. Mathematical models of routing. Decision variables, objective functions – alternatives – constraints - flight coverage, aircraft available. Example problems and solutions
CREW AND MANPOWER SCHEDULING : Crew scheduling process – significance. Development of crew pairing – pairing generators – mathematical formulation of crew pairing problem – methods of solution, Crew rostering – rostering practices – the crew rostering problem – formulation, solutions. Manpower scheduling, modeling, formulation of the problem, solutions

UNIT – IV:
GATE ASSIGNMENT : Gate assignment – significance – the problem - levels of handling – passenger flow, distance matrix-mathematical formulation, solution.
AIRLINE IRREGULAR OERATION, DISRUPTION OF SCHEDULE AND RECOVERY : The problem statement, the time band approximation model – formulation of the problem – the scenarios – solution.

UNIT – V:
COMPUTATIONAL COMPLEXITY, CASE STUDIES OF AIRLINE OPERATIONS AND SCHEDULING AND SIMULATION : Complexity theory, heuristic procedures. Case studies of airline operation and scheduling – study through simulation modeling – use of available software.

TEXT BOOKS

1. *Airline operations and Scheduling*, Bazargan, M., Ashgate, 2004, ISBN 0-7546-3616-X.
2. *Operations Research in Airlines Industry*, Yu, G.,Kluwer Academic Publishers, 1998.
3. *Network Flows – Theory, Algorithms and Applications,* Ahuja, R. et al., Prentice Hall, 1993.

REFERENCES

1. *Handbook of Optimization,* Paradalos, P.M. and Resende, M.G.C., Oxford Univ. Press, New York, 1993.
2. www.airlinestechnology.net

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – I Sem. Aerospace Engg.

ROTORCRAFT AERODYNAMICS
(ELECTIVE-II)

Aim: The student shall be given advance understanding of rotorcraft aero dynamics.

Outcome: The student will be able to solve engineering problems rotorcraft aero dynamics.

UNIT-I:
FUNDAMENTALS OF ROTOR AERODYNAMICS, BLADE ELEMENT ANALYSIS: Momentum theory analysis in hovering flight, Disk loading and power loading, Induced inflow ratio, Thrust and power coefficients, Comparison of theory with measured rotor performance, Non-ideal effects on rotor performance, Figure of merit, Induced tip loss, Rotor solidity and blade loading coefficients, Momentum analysis in axial climb and descent, Momentum analysis in forward flight, Blade Element Analysis in hover and axial flight, forward flight

UNIT-II:
ROTATING BLADE MOTION: Types of rotors, Equilibrium about the flapping hinge and lead-lag hinge, Equations of motion for a flapping blade, Blade feathering and the swashplate, Dynamics of a lagging blade with a hinge offset, Coupled flap-lag motion, Coupled pitch-flap motion, Other types of rotors, Introduction to rotor trim
HELICOPTER PERFORMANCE: Hovering and axial climb performance, Forward flight performance, Performance analysis, Autorotational performance, Vortex ring state(VRS), Ground effect, Performance in maneuvering flight, Factors influencing performance degradation

UNIT-III:
AERODYNAMIC DESIGN OF HELICOPTERS: Overall design requirements, Conceptual and preliminary design processes, Design of the main rotor, Fuselage aerodynamic design issues, Empennage design, Role of wind tunnels in aerodynamic design, Design of tail rotors, Other anti-torque devices, High speed rotorcraft, Smart rotor systems, Human-powered helicopter, Hovering micro air vehicles
AERODYNAMICS OF ROTOR AIRFOILS: Helicopter rotor airfoil requirements, Reynolds number and Mach number effects, Airfoil shape definition, Airfoil pressure distribution, Aerodynamics of a representative airfoil section, Pitching moment and related issues, Drag, Maximum lift and stall characteristics, Advanced rotor airfoil design, Representing static airfoil characteristics, Circulation controlled airfoils, Very low Reynolds number airfoil characteristics, Effects of damage on airfoil performance

UNIT-IV:
UNSTEADY AIRFOIL BEHAVIOR: Sources of unsteady aerodynamic loading, Concepts of blade wake, Reduced frequency and reduced time, Unsteady attached flow, Principles of quasi-steady thin airfoil theory, Theodorsen’s theory, Returning wake-Loewy’s problem, Sinusoidal gust-Sear’s problem, Indicial response-Wagner’s problem, Sharp edged gust-Kussner’s problem, Traveling sharp edged gust- Milne’s problem, Time varying incident velocity, Indicial method for subsonic compressible flow, Non-uniform vertical velocity fields, Time-varying incident Mach number, Unsteady aerodynamics of flaps, Principles of noise produced by unsteady forces,

UNIT-V:
DYNAMIC STALL: Flow morphology of dynamic stall, Dynamic stall in the rotor environment, Effects of forcing conditions on dynamic stall, Modeling of dynamic stall, Torsional damping, Effects of sweep angle, airfoil shape on dynamic stall, Three dimensional effects on dynamic stall, Time-varying velocity effects on dynamic stall, Prediction of in-flight airfoils, Stall control
ROTOR WAKES AND BLADE TIP VORTICES, ROTOR-AIRFRAME INTERACTIONAL AERODYNAMICS:

Characteristics of rotor wake in hover and forward flight, Vortex models of rotor wake, Aperiodic wake developments, General dynamic inflow models, Descending flight and vortex ring state, Wake developments in maneuvering flight; Rotor-fuselage interactions, Rotor-empennage interactions, Rotor-tail rotor interactions

TEXT BOOK

1. *Principles of Helicopter Aerodynamics,* Second Edition, J. Gordon Leishman, Cambridge University Press, 2006, ISBN 0-521-85860-7

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – I Sem. Aerospace Engg.

DIGITAL SIMULATION LAB - I

I. MATLAB/ Simulink Fundamentals for Aerospace Applications

Aim:
The student shall be asked to solve various aero space application problems in MATLAB and fluent environment.

Outcome:
The student will gain hands on experience in MATLAB and fluent applications and can be capbule of simulating aero space engineering issues.

MATLAB introduction, Plotting and graphics: Plot, log and semi-log plots, polar plots,
Subplots, axis, mesh, contour diagrams, flow diagrams, movies, MATLAB Toolboxes: Continuous transfer functions, root locus, Nichols chart, Nyquist chart, linear quadratic regulator, state-space design, digital design, Aerospace toolbox; M Cells, Structures and M-files, MEX-files,

Standard Simulink libraries, Simulink aerospace blockset, Building Simulink linear models: transfer function modeling in Simulink, zero pole model, state-space model; Simulink LTI viewer and usage of it, equivalent Simulink LTI models, Single-Input, Single-Output(SISO) design tool, Building Multi-Input, Multi –Output models, Building Simulink S-functions; Stateflow introduction: Opening, executing, and saving stateflow models, constructing a simple stateflow model, using a stateflow truth table

II. Software Development for Simulation of Fluid Flows

- Generation of structured and unstructured grids in two and three dimensions
- Solution of Burgers equation using explicit MacCormack method
- Blasius solution for laminar boundary layer over a flat plate
- Riemann solver for shock tube problem

III. Flow Simulation using FLUENT

- Simulation of Flow past airfoils and wings
- Simulation of Compressible flow in convergent-divergent nozzle
- Simulation of compressible flow in a compressor

REFERENCES

1. *Basic MATLAB, Simulink, and State Flow, Richard Colgren*, AIAA Education Series, 2007
2. *Introduction to Simulink with Engineering Applications*, Steven T. Karris, Orchard Publications, 2006, ISBN –9744239-8-X
3. *Computational Fluid Mechanics and Heat Transfer,* Second Edition, John C. Tannehill, Dale A. Anderson, Richard H. Pletcher, Taylor & Francis Publication, 1997.
4. *Computational Fluid Dynamics,* T. J. Chung, Cambridge University Press, 2002

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

AIRCRAFT CONTROL AND SIMULATION

Aim and Objectives: The course provides advance knowledge in aircraft dynamics control and simulation. Every unit of the course starts with the basics on the topic and ends with advance topics. This will help students to appreciate the course in coherent fashion.

Outcome: At the end of this course student would be in a position to work on advance research and development projects on aircraft dynamics and control.

UNIT-I:

The Kinematics And Dynamics Of Aircraft Motion : Vector Kinematics, Matrix Analysis of Kinematics, Geodesy, Earth's Gravitation, Terrestrial Navigation, Rigid-Body Dynamics.

UNIT-II:

Modeling The Aircraft: Basic Aerodynamics, Aircraft Forces and Moments, Static Analysis, The Nonlinear Aircraft Model, Linear Models and the Stability Derivatives.

Modeling, Design And Simulation Tools: State Space Models, Transfer Function Models, Numerical Solution of the State Equations, Aircraft Models for Simulation, Steady State Flight, Numerical Linearization.

UNIT-III:

Aircraft Dynamics : Aircraft Dynamic Behavior, Aircraft Rigid Body Modes, The Handling Qualities Requirements, Stability Augmentation Systems

: Control Design Feedback Control, Control Augmentation Systems, Autopilots and Flight management systems, Nonlinear Simulation.

UNIT-IV:

Modern Design Techniques : Assignment of Closed-Loop Dynamics, Linear Quadratic Regulator with Output Feedback, Tracking a Command, Modifying the Performance Index, Model Following Design, Linear Quadratic Design with Full State Feedback, Dynamic Inversion Design.

UNIT-V:

Robustness And Multivariable Frequency Domain Techniques: Multivariable Frequency Domain Analysis, Robust Output Feedback Design, Observers and the Kalman Filter, LQG/Loop Transfer Recovery.

Digital Control : Simulation of Digital Controllers, Discretization of Continuous Controllers, Modified Continuous Design, Implementation Considerations.

TEXT BOOK

1. *Aircraft Control and Simulation,* Brian L. Stevens and Frank L. Lewis, John Wiley & Sons, 2003

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. Aerospace Engg.

SPACE TRANSPORTATION SYSTEMS

UNIT-I:
Systems Engineering and Systems Design Considerations: Introduction, Systems engineering definition, System engineer, Systems engineering cycle, Systems engineering process, Doctrine of successive refinement, Systems engineering in a DOD Context, Systems Engineering in a NASA Context, Systems Design Considerations: Overview of design process, System integration, System interfaces and control, Tools and methodologies, Systems analysis, Modeling, and the trade study process, Basic launch vehicle system trade analysis methodology, System effective studies

UNIT II:
Transportation System Architecture, Infrastructures and U.S. Space Shuttle: Introduction, Historical drivers for space infrastructure, Political considerations, National mission model, Private sector and commercialization, Development of commercial space transportation architecture and system concepts, Cost drivers for space transportation architecture options, Recommended improvements to space transportation architectures, Planning for future space infrastructure, Transportation Infrastructure for moon and mars missionsU.S. Space Shuttle: Introduction, Historical background, Development of shuttle system, Orbiter development, Current shuttle vehicle and operations, Shuttle evolution and future growth,

UNIT-III:
Expendable Space Transportation Systems and Reusable Space Launch Vehicles: Introduction, Expendable launch vehicle design, History behind existing Expendable Launch Vehicles, Evolving the expendable launch vehicle, Reusable space launch vehicles: Background—Previous efforts at hypersonic flight, Early aerospace plane conceptual studies, The X-series of research aircraft, Challenges facing manned aerospace planes, Manned reusable systems development programs-Past and Ongoing., NASA reusable launch vehicle studies in 1990s., Hypersonic waveriders, Importance of vehicle health management, Future reusable space launch vehicles
Operations and Support Systems: Introduction, Launch operations definition, Shuttle mission operations, Facility requirements for launch operations, Obstacles to streamlining launch operations, Evolutionary launch operations strategies, Designing for future expendable launch vehicle launch operations, Improving Existing Launch Operations, Future launch operations

UNIT IV:
Systems and Multidisciplinary Design Optimization : Introduction, Launch vehicle conceptual design problem, Modeling needs, Optimization strategies and applications, Collaborative work environment of the future
Systems Technology Development: Introduction, Vehicle technologies, Propulsion technologies, Ground and mission operations technologies, Assessing technological options, Technology transfer and commercialization, Applying a commercial development process for access to space

UNIT V:
Program Planning, Management, and Evaluation: Introduction, Management Trends, Good Project Management as Team Building and a Balancing Act, Types of Project Management, Configuration Management, Risk Management, Earned value management, Total Quality Management, Managing ultra-large projects
Future Systems: Introduction, Next generation space transportation systems, Accelerator concepts, Nuclear fission and fusion based concepts, Antimatter-based propulsion concepts, Solar propulsion concepts, Laser and beamed energy propulsion Concepts, Magnetic Monopoles Concept, Field and Quantum Effect Propulsion Concepts.

Text Book

1. ***S****pace Transportation: A Systems Approach to Analysis and Design,* Walter Hammond, AIAA Education Series, American Institute of Aeronautics and Astronautics, Inc, 1999.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

COMPUTATIONAL APPROACHES TO AEROSPACE VEHICLE DESIGN

UNIT-I:

Principles Of Aerospace Design: Historical Perspective on aerospace design, Traditional manual approaches to design and design iteration, Design teams, Advances in modeling techniques, Tradeoffs in aerospace system design, Design automation, evolution and innovation, Design search and optimization, Take-up of computational methods, Design oriented Analysis: Geometry modeling and design parameterization, Computational mesh generalization, Analysis and design of coupled systems

UNIT-II:

Elements Of Numerical Optimization-I: Single variable optimizers- line search, Multi variable optimizers: Population versus single point methods, Gradient based methods, Noisy/Approximate function values, Non-gradient based algorithms, Termination and convergence aspects, Constrained optimization, Problem transformations, Lagrange multipliers, Feasible directions method, Penalty function methods, Combined Lagrangian and penalty function methods, Sequential quadratic programming, Chromosome repair

UNIT-III:

Elements Of Numerical Optimization-II: Meta models and Response surface methods: Global versus local meta models, Meta modeling tools, Simple RSM examples, Combined approaches-Hybrid searches and meta heuristics, Multi-objective optimization, Multi-objective weight assignment techniques, Methods for combining goal functions, fuzzy logic and physical programming, Pareto set algorithms

Sensitivity Analysis: Finite-difference methods, Complex variable approach, Direct methods, Adjoint mehods, Semi-analytical methods, Automatic differentiation

UNIT-IV:

Approximation Concepts: Local approximations, Multipoint approximations, Black-box modeling, Generalized linear models, Sparse approximations techniques, Gaussian process interpolation and regression, Data parallel modeling, Design of experiments, Surrogate modeling using variable fidelity models, Reduced basis methods

Design Space Exploration-Surrogate Models: Managing surrogate models in optimization: Trust regions, Space mapping approach, Surrogate assisted optimization using global models, Managing surrogate models in evolutionary algorithms

UNIT-V:

Design In The Presnce Of Uncertainty: Uncertainty modeling and representation, Uncertainty propagation, Taguchi methods, Welch-Sacks method, Design for six sigma, decision theoretic formulations, Reliability-based optimization, Robust design using information-gap theory, Evolutionary algorithms for robust design

Multi-Disciplinary Optimization: Multi-disciplinary analysis, Fully integrated optimization, System decomposition and optimization, Simultaneous analysis and design, Distributed analysis optimization formulation, Collaborative optimization, Concurrent subspace optimization, Co-evolutionary architectures

TEXT BOOK

1. *Computational Approaches for Aerospace Design-The Pursuit of Excellence*, Andy J. Keane, Prasanth B. Nair, John Wiley & Sons, 2005, ISBN 10:0-470-85540-1

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

AEROSPACE SENSORS AND MEASUREMENT SYSTEMS

UNIT-I:

Introduction To Experimental Methods: Characteristics of Measuring systems:: Readability, Sensitivity, Hysteresis, Accuracy, Precision: Calibration, Standards, Experiment planning, Causes and types of experimental errors, Statistical analysis of experimental data

UNIT II:

Flow Measurements: Pressure Measurement: Manometer, Pressure transducers, Scanning valves; Temperature Measurement: Thermometers, Thermocouples, Thermopiles, Keil probes; Velocity Measurement: Pitot probes, Hot wires, 7 hole probes, Laser Doppler Velocimetry (LDV), Particle Image Velocimetry (PIV), Doppler Global Velocimetry(DGV) ; Turbulence Measurements: LDV, Hot wire anemometers, Root Mean Square(RMS), Spectrum;

Flow Visualization: Path-, Streak-, Stream-, and Time lines, Direct visualization, Surface flow visualization, Flow field visualization, Data driven visualization

UNIT-III:

Forces And Moments From Wind Tunnel Balance Measurements : Types of wind tunnels, Aeronautical wind tunnels, Wind tunnel data systems, Balances, Balance requirements and specifications, External balances and internal balances

Stress And Strain Measurements: Stress and strain, Strain measurements, Strain gauge types, Basic characteristics of of a strain gage, Electrical resistance strain gauges, Rosette analysis, Strain gauge sensitivity, Stress gauges

UNIT IV

Motion And Vibration Measurement: Two simple vibration instruments, Principles of seismic instrument, Practical considerations for seismic instruments, Sound measurements

Motion And Inertial Measurements: Applications of accelerometer sensors, Acceleration sensing principles, Pendulous accelerometer (open and closed loop), Micro-machined accelerometer, Piezoelectric accelerometer, Rate gyroscope principles, Rate-integrating gyroscope principles, Micro-gyro sensors, Laser gyros

UNIT-V:

Spacecraft Attitude Determination Sensors: Infrared earth sensors-Horizon Crossing Sensors, Sun sensors, Star sensors, Rate and rate integrating gyros, Magnetometers

TEXT BOOKS

1. *Experimental Methods for Engineers,* Seventh Edition, J. P. Holman, Tata McGraw Hill, 2004
2. *Measurement Systems-Application and Design,*5th Edition, Ernest O Doebelin, Dhanesh N Manik, Tata McGraw Hill, 2007
3. *Low-Speed Wind Tunnel Testing,* Jewel B Barlow, William H. Rae,Jr. , Alan Pope, John Wiley, Third Edition, 1999
4. *Spacecraft Dynamics and Control-A Practical Engineering Approach,* Marcel J. Sidi, Cambridge University Press, 1997

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

AEROTHERMODYNAMICS OF HYPERSONIC FLIGHT
(Elective-III)

UNIT I:
GENERAL CHARACTERIZATION OF HYPERSONIC FLOWS

Defining hypersonic flow, Characterizing hypersonic flow using fluid dynamic phenomenon. Basic Equations of Motion**:** Equilibrium and non-equilibrium flows, Equilibrium conditions, Dependent variables, Transport properties, Continuity, momentum and energy equations, General form of the equations of motion in conservation form.

UNIT II:

Defining The Aerothermodynamic Environment: Empirical correlations complemented by analytical techniques, General comments about CFD, Computations based on a two layer flow model, Techniques treating entire shock layer in a unified fashion, Calibration and validation of the CFD codes

Experimental Measurements Of Hypersonic Flows: Ground-based simulation of hypersonic flows, Ground-based hypersonic facilities, Experimental data and model design considerations, Flight tests, Importance of interrelating CFD, ground-test data and flight-test data

UNIT III:

Stagnation-Region Flow Field: Stagnating streamline, Stagnation-point convective heat transfer, Radiative heat flux

Pressure distribution: Newtonian flow models, Departure from the Newtonian flow field, Shock-Wave / Boundary Layer (Viscous) Interaction for two-dimensional compression Ramps, Tangent-Cone and Tangent-Wedge approximations, Need for more sophisticated models, Pressure distributions for a reacting gas, Pressures in separated regions

UNIT IV:

Boundary layer and convective heat transfer: Boundary Conditions, Metric or equivalent cross-section radius, Convective heat transfer and skin friction, Effects of surface catalycity, Base heat transfer in separated flow

Viscous interactions: Compression ramp flows, Shock/Shock interactions, Flow field perturbations around swept fins, Corner flows, Examples of Viscous Interactions for Hypersonic Vehicles: X-15, Space shuttle orbiter, Hypersonic air-breathing aircraft

UNIT V:

Aerodynamic Forces And Moments & Design Considerations Of Hypersonic Vehicles: Newtonian Aerodynamic Coefficients, Re-entry capsule aerodynamics, Shuttle orbiter aerodynamics, X-15 Aerodynamics, Hypersonic aerodynamics of research plane, Dynamic stability considerations; Design Considerations: Reentry vehicles, Design philosophy, Design considerations for rocket-launched/glide reentry vehicles, airbreathing vehicles, combined rocket/airbreathing powered vehicles, Design of a new vehicle

TEXTBOOKS

1. *Hypersonic Aerothermodynamics*, John J. Bertin, AIAA Education Series, 1994.

REFERENCE BOOKS

1. *Hypersonic and High Temperature Gas Dynamics***,** Second Edition, J. D. Anderson, AIAA Eucation Series, 2006
2. *Basics of Aerothermodynamics***,** Ernst Heinrich Hirshchel, Springer-Verlag, 2005

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. Aerospace Engg.

DYNAMICS AND CONTROL OF STRUCTURES
(Elective-III)

Aim and Objectives: The course is multidisciplinary in nature and is a combination of rigid and flexible body dynamics and controls. The course would provide analysis and design methodologies using both classical and modern approaches. For flexible body dynamics, distributed control theory is introduced.

Outcome: The course will provide sufficient background to help students to analyze and design practical control system for mechanical and aerospace applications.

UNIT-I:
Newtonian Mechanics: Newton's Second Law, Impulse and Momentum, Moment of a Force and Angular Momentum, Work and Energy, Systems of Particles, Rigid Bodies, Euler's Moment Equations.

UNIT-II:
Principles Of Analytical Mechanics: Degree of Freedom and Generalized Coordinates, The Principle of Virtual Work, D'Alembert's Principle, Hamilton's Principle, Lagrange's Equations of Motion, Hamilton's Canonical Equations, Motion in the Phase Space, Lagrange's Equations of Motion in Terms of Quasi-Coordinates.
Concepts From Linear System Theory: Concepts from System Analysis, Frequency Response, Response by Transform Methods, The Transfer Function, Singularity Functions, Response to Singularity Functions, Response to Arbitrary Excitation, The Convolution Integral, State Equations. Linearization about Equilibrium, Stability of Equilibrium Points , Response by the Transition Matrix, Computation of the Transition Matrix, The Eigenvalue Problem, Response by Modal Analysis, State Controllability, Output Equations, Observability, Sensitivity of the Eigensolution to Changes in the System Parameters, Discrete-Time Systems.

UNIT-III:
Lumped-Parameter Structures: Equations of Motion for Lumped-Parameter Structures, Energy Considerations, The Algebraic Eigenvalue Problem, Free Response, Qualitative Behavior of the Eigensolution, Computational Methods for the Eigensolution, Modal Analysis for the Response of Open-Loop Systems.
Control of lumped-parameter systems. Classical approach: Feedback Control Systems, Performance of Control Systems, The Root-Locus Method, The Nyquist Method, Frequency Response Plots, Bode Diagrams, Relative Stability. Gain Margin and Phase Margin, Log Magnitude-Phase Diagrams, The Closed-Loop Frequency Response. Nichols Charts, Sensitivity of Control Systems to Variations in Parameters, Compensators, Solution of the State Equations by the Laplace Transformation

UNIT-IV:
Control of lumped-parameter systems. Modern approach: Feedback Control Systems, Pole Allocation Method, Optimal Control, The Linear Regulator Problem, Algorithms for Solving the Riccati Equation, The Linear Tracking Problem, Pontryagin's Minimum Principle, Minimum-Time Problems, Minimum-Time Control of Time-Invariant Systems
Minimum-Fuel Problems, Simplified On-Off Control, Control Using Observers, Optimal Observers. The Kalman-Bucy Filter, Direct Output Feedback Control, Modal Control

UNIT-V:
Distributed-Parameter Structures, Exact And Approximate Methods: Boundary-Value Problems, The Diffenrential Eigenvalue Problems, Rayleigh's Quotient, The Rayleigh-Ritz Method, The Finite Element Method, The Method of Weighted Residuals, Substructure of Undamped Structures, Damped Structures.
Control Of Distributed Structures: Closed-Loop Partial Differential Equation of Motion, Modal Equations for Undamped Structures, Mode Controllability and Observability, Closed-Loop Modal Equations, Independent Modal-Space Control, Coupled Control, Direct Output Feedback Control,

Systems with Proportional Damping, Control of Discretized Structures, Structures with General Viscous Damping.

TEXT BOOK

1. *Dynamics and Control of Structures*, Leonard Meirovitch, John Wiley & Sons, 1990

REFERENCE BOOKS

1. *Introduction to Structural Dynamics and Aeroelasticity*, Dewey. H. Hodges, G.Alvin Pierce- Cambridge University Press, 2002
2. *Structural Dynamics in Aeronautical Engineering*, Maher N. Bismarck-Nasr, AIAA Education Series, 1999
3. *Adaptive Structures: Engineering Applications*, David Wagg, Ian Bong, Paul Weaver, Michael Friswell (eds) , John Willey & Sons, Ltd, 2007

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

MISSILE GUIDANCE
(ELECTIVE-III)

Aim:
The student shall be explained fundamental and advanced concepts of missile guidance.

Outcome:
The student will get thorough insights into various aspects of missile guidance.

UNIT-I:
Fundamentals Of Tactical Missile Guidance: Proportional navigation, Simulation of proportional navigation in two dimensions, Two-dimensional engagement simulation, Linearization, Linearized engagement simulation, Important closed-form solutions, Proportional navigation and zero effort miss

UNIT-II:
Method Of Adjoints And The Homing Loop: Homing loop, Single time constant guidance system, Construction of an adjoint, Adjoint mathematics, Adjoints for deterministic systems, Deterministic adjoint example, Adjoint closed-form solutions, Normalization
Noise Analysis, Covariance Analysis And The Homing Loop: Basic definitions, Gaussian noise example, Computational issues, Response of linear system to white noise, Low-pass-filter example, Adjoints for noise-driven systems, Shaping filters and random processes, Example of a stochastic adjoint, Closed-form solution for random target maneuver, Covariance analysis theory, Low-pass filter example, Numerical considerations, Homing loop example, Acceleration adjoint

UNIT-III:
Proportional Navigation And Miss Distance: System order, Design relationships, Optimal target evasive maneuvers, Practical evasive maneuvers, Saturation, Parasitic effects, Thrust vector control
Advanced Guidance Laws: Review of proportional navigation, Augmented proportional navigation, Derivation of augmented proportional navigation, Influence of time constants, Optimal guidance

UNIT-IV:
Kalman Filters And The Homing Loop: Theoretical equations of Kalman filter, Application to homing loop, Kalman gains, Numerical examples, Experiments with optimal guidance
Other Forms Of Tactical Guidance, Tactical Zones: Proportional navigation command guidance, Beam rider guidance, Command to line-of- sight guidance; Tactical Zones: Velocity computation, Drag, Acceleration, Gravity

UNIT-V:
Strategic Considerations, Boosters, And Lambert Guidance: Strategic Considerations: Gravitational model, Closed form solutions, Hit equation, Flight time; Boosters: Staging, Booster numerical example, Gravity turn; Lambert Guidance: Statement of Lambert's problem, Solution to Lambert's problem, Numerical example, Booster steering, General energy management steering

TEXT BOOK

1. *Tactical and Strategic Missile Guidance*, Fifth Edition, Paul Zarchan, Progress in Astronautics and Aeronautics, AIAA, 2007, ISBN-10: 1-56347-874-9

REFERENCE BOOK

1. *Missile Guidance and Control Systems*, George M. Siouris, Springer-Verlag, 2004, ISBN: 0-387-00726-1

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. Aerospace Engg.

ADVANCED TOPICS IN AIR TRAFFIC MANAGEMENT SYSTEMS (ELECTIVE-III)

Aim:
To impart understanding of advanced topics aim air traffic management including HR aspects.

Outcome:
The student will appreciate multi dimensional aspects of operations and systems.

UNIT- I:
Air Traffic Management: Introduction: Air traffic services provided to aircraft operators, Government responsibilities, Flight rules and airspace organization, Airways and procedures, Phases of flight, Subsystems of ATM system, Facilities and operation, System capacity, Airborne collision avoidance systems, Future trends, Capacity driven operational concept of ATM.

UNIT-II:
Economics Of Congestion: Impact of ATM on airspace user economic performance, Effects of schedule disruptions on the economics of airline operations, Modeling of an airline operations control center.
Collaborative Decision Making: Effect of shared information on pilot controller and controller- controller interactions, Modeling of distributed human decision making in traffic flow management operations.

UNIT-III:
Airport Operations And Constraints : Analysis, modeling and control of ground operations at airports, Collaborative optimization of arrival and departure traffic flow management strategies at airports.
Airspace Operations And Constraints : Performance measures of air traffic services, Identification of airport and airspace capacity constraints.

UNIT-IV:
Safety And Free Flight : Accident risk assessment for advanced air traffic management, Airborne separation assurance systems. Human factors
Cognitive Workload Analysis And Role Of Air Traffic Controller: Task load measures of air traffic controllers, Technology enabled shift in controller roles and responsibilities.

UNIT-V:
Aircraft Self Separation : Cooperative optimal airborne separation assurance in free flight airspace, Automatic dependent surveillance broadcast system - operational evaluation.

TEXT BOOKS

1. *Fundamentals of Air Traffic Contro*l, Fourth edition, Nolan, M.S., Thomson Learning, 2004, ISBN-13:978-0-534-39388-5.
2. *Air Transportation Systems Engineering*, Donohue, G. L. et al., (Editors), AIAA, 20003, ISBN 1-56347-474-3
3. *Avionics Navigation Systems*, Keyton, M. and Fried, W. R., John Wiley, 2001, ISBN 0-471-54795-6

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. Aerospace Engg.

SPACECRAFT DYNAMICS AND CONTROL
(Elective-III)

UNIT-I:
Orbit Dynamics: Basic physical principles, Two body problem, Moment of momentum, Equation of motion of a particle in a central force field, Time and Keplerian orbits, Keplerian orbits in space, Perturbed orbits: Non-Keplerian orbits, Perturbing forces and their influence on the orbit, Perturbed geostationary orbits, Euler – Hill equations.

UNIT-II:
Orbital Maneuvers: Single-impulse orbit adjustment., Multiple-impulse orbit adjustment, Geostationary orbits, Geostationary orbit corrections .
Attitude Dynamics And Kinematics: Angular momentum and inertia matrix, Rotational kinetic energy of a rigid body, Moment of inertia matrix in selected axis frame, Euler's moment equations, Characteristics of rotational motion of a spinning body, Attitude kinematics equations of motion of a spinning body, Attitude dynamic equations of motion for a nonspinning satellite

UNIT-III:
Gravity Gradient Stanilization: Basic attitude control equation, Gravity gradient attitude control
Single- And Dual-Spin Stabilization: Attitude stabilization during the ΔV stage, Active nutation control, Estimation of fuel consumed during active nutation control, Despinning and denutation of a satellite, Single spin stabilization, dual spin stabilization

UNIT-IV:
Attitude Maneuvers In space : Equations for basic control laws, Control with momentum exchange devices, Magnetic attitude control, Magnetic unloading of momentum exchange devices, Time-optimal attitude control, Technical features of the reaction wheel.
Momentum-Biased Attitude Stabilization: Stabilization with and without active controls, Roll-yaw attitude control with two momentum wheels, Reaction thruster attitude control

UNIT-V:
Reaction Thruster Attitude Control: Set up of reaction thruster control, Reaction torques and attitude control loops, feed back control loops, Reaction attitude control via pulse width modulation, Reaction control system using only four thrusters, Reaction control and structural dynamics.

TEXT BOOK

1. *Spacecraft Dynamics and Control*, Marcel J. Sidi, Cambridge University Press, 1997

REFERENCES

1. Modern Spacecraft Dynamics & Control, M. H. Kaplan, Wiley, 1976,
2. Space Vehicle Dynamics and Control., B. Wie, AIAA, 1998
3. Spacecraft Attitude Determination and Control, J. R. Wertz, editor, D. Reidel Publishing, 1978

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. Aerospace Engg.

ROCKET AND SPACECRAFT PROPULSION
(ELECTIVE-IV)

UNIT-I:
Fundamentals Of Rocket Propulsion : Applications of Rockets, Multistage Rockets, Orbits and Spaceflight, Basics of Thermal Rocket Engine-Thermodynamics and Performance Analysis, Types of Rockets – Propellants, Selection of Rocket Propulsion Systems, Selection of Rockets Depending on Mission Requirements

UNIT-II:
Solid Propellant Rockets : Solid Propellant Rockets, Basic Configuration and Performance, Propellant Grain and Configuration, Propellant Characteristics, Properties and Design of Solid Motors, Combustion Chamber, Ignition Process and Instability, Thrust Vector Control, Two Modern Solid Boosters: Space Shuttle SRB, Ariane MPS
Liquid Propellant Rockets : Liquid Propellant Rockets Basics, Propellants and Feed Systems, Combustion chamber and Nozzle, Propellant Distribution Systems, Thrust Chambers, Injectors, Combustion Instability, Performance of Liquid Rockets, Performance Analysis, Cryogenic Propellants, Liquid Propellant Rocket Engines: Ariane Engine-Viking, HM7 B, Vulcan, Space Shuttle Main Engine- RS 68, RL 10.

UNIT-III:
Advanced Thermal Rockets : Improving Efficiency, Single stage to orbit concepts, Practical approaches and developments, Vehicle Design and Mission Concept, Hybrid Propellant Rockets, Performance analysis and Configuration, Rocket Exhaust Plumes and Nozzles, Apollo 11 Case study, Orion Spacecraft and GSLV
Electric Propulsion : Electric Propulsion Principles, Electro-thermal thrusters-Performance and importance of Exhaust Velocity, Arc-Jet Thrusters, Electromagnetic Propulsion: Ion Propulsion, Propellant Choice and Performance, Ion Thrust and Electrical Efficiency, Mission Applications- Engine Examples, SMART I and PPS-1350.

UNIT-IV:
Plasma Thrusters: Basic Plasma Physics, Hall effect thrusters and Radio frequency thrusters, Low Power Electric thrusters, Electric Power Generation: Radio Active Thermal generators, Ideal and Optimal Flight Performance of Electric Propulsion, Applications, Station Keeping, Transfer orbits, Gravity loss and thrust, Electric Propulsion Engine Examples: Deep Space I, NSTAR Ion Engine.
Nuclear Propulsion: Nuclear Fission Basics, Sustainable Chain Reaction, Power, Thrust and Energy, Neutron leakage and control, Thermal Stability, Principle of Nuclear Thermal Propulsion, Performance and Working of Nuclear Rocket Engine, Potential Applications and Operational issues, Nuclear Propelled Missions

UNIT-V:
Advanced Propulsion Concepts: Pulse Detonation Engine, Antimatter Propulsion, Traveling at Relativistic Speeds, Fusion Propulsion, Superluminal Speed, Deep space Programs, Solar sails, Space Elevators

TEXT BOOKS

1. *Rocket and Spacecraft Propulsion: Principles, Practice and New Developments,* Martin J. L. Turner, 3rd Edition, Springer Publishing, 2008.
2. *Rocket Propulsion Elements*, Seventh Edition, George P. Sutton and Oscar Biblarz. , John Wiley & Sons, 2001.
3. *Advanced Space Propulsion Systems*, Martin Tajmer, Springer Publication, 2004.

REFERENCE BOOKS

1. *Fundamentals of Electric Propulsion,* Goebel M., Katz Ira, John Wiley Publications, 2008.
2. *Future Spacecraft Propulsion Systems*, Second Edition, Paul A. Czysz and Claudio Bruno, Springer-Praxis, 2009
3. *Space Transportation: A System Approach to Analysis and Design*, Hammond E.W, AIAA Education Series, 2005

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

MECHANICS OF COMPOSITE MATERIALS
(Elective-IV)

Aim and Objectives: The course provides basic knowledge of composite laminates starting form micro- and macro-mechanics, constitutive relationship, to normal force-strain and moment-curvature relationship. Subsequently, laminated thin plate theory is developed and used for deflection, stress and buckling analysis. Finally, methodologies for composite structural design are presented.

Outcome: At the end of the course students would be in a position to do analysis and design of composite structures using laminated thin plate theory.

UNIT- I:
Introduction To Composite Materials: Classification and characteristics, Mechanical behavior of composite materials, Basic terminology, Manufacture of laminated fiber-reinforced composite materials, Current and potential advantages of fiber-reinforced composite materials, Applications of composite materials.

UNIT II:
Macromechanical Behavior Of A Lamina: Introduction, Stress-strain relations for anisotropic materials, Stiffnesses, compliances, and engineering constants for orthotropic materials, Restrictions on engineering constants, Stress-strain relations for plane stress in an orthotropic material, Stress-strain relations for a lamina of arbitrary orientation, Invariant properties of an Orthotropic lamina, Strengths of an Orthographic lamina, Biaxial strength criteria for an Orthotropic lamina

UNIT- III:
Micromechanical Behavior Of Lamina: Introduction, Mechanics of materials approach to stiffness, Elasticity approach to stiffness, Comparison of approaches to stiffness, Mechanics of materials approach to strength
Macromechanical Behavior Of Laminates - I : Introduction, Classical lamination theory, Special cases of laminate stiffness, Theoretical versus measured laminate stiffness

UNIT IV:
Macromechanical Behavior Of Laminates – II : Strength of laminates, Inter-laminar stresses
Bending And Buckling Of Laminated Plates: Introduction, Governing equations, Deflection of simply supported laminated plates, Under distributed transverse load, Buckling of simply supported laminated plates under in-plane load

UNIT V:
Introdution To Design Of Composite Structures – I; Introduction to structural design, Materials selection, Configuration selection
Introdution To Design Of Composite Structures – II: Laminate joints, Design requirements and design failure criteria, Optimization concepts, Design analysis philosophy for composite structures

TEXT BOOK
1. *Mechanics of Composite Materials*, Robert. M. Jones, Second Edition, Taylor and Francis, 1999

REFERENCE BOOKS
1. *Mechanics of Fibrous composites*- Carl. T. Herakovich-John Wiley & Sons, 1997.
2. *Advanced Composite Materials*, Lalit Gupta, Himalayan Books. New Delhi, 1998

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

TACTICAL MISSILE DESIGN
(Elective-IV)

Aim:

Tactical missile design is taught from the point of view of structural, Geometry, Mass and propulsion optimization.

Outcome:

The student can take up problems in tactical missile design.

UNIT-I:

Introduction / Key Drivers In Design Process: Tactical Missile characteristics, Conceptual design process, Examples of State-of-the-Art missiles, Aerodynamic configuration sizing parameters, Examples of alternatives in establishing mission requirements, Baseline missile

UNIT-II:

Aerodynamic Considerations In Tactical Missile Design: Missile diameter tradeoff, Nose fineness tradeoff, Boat-tail, Lifting body versus axi-symmetric body, Wings versus no wings, Normal force prediction for surfaces, Wing aerodynamic center prediction, Wing drag prediction, Surface planform geometry tradeoffs, Flight control alternatives, Maneuver alternatives, Roll orientation, Static stability, Tail area sizing, Stability and control conceptual design criteria, Body buildup

Propulsion Considerations In Tactical Nissile Design: Propulsion alternatives assessment, Ideal ramjet Mach number and temperature technology limit, Ramjet specific impulse prediction, Ramjet thrust prediction, Ramjet engine/booster integration, Ramjet inlet options, Ramjet inlet spillage, Inlet shock loss, Ramjet missile drag due to booster integration, Fuel alternatives, Rocket motor performance, Solid motor grain alternatives, Solid rocket thrust control, Solid propellant material alternatives, Motor case alternatives, Rocket nozzle material alternatives

UNIT-III:

Weight Considerations In Tactical Missile Design: Benefits of lighter weight missile, Subsystem weight sensitivity to flight performance, Missile weight prediction, Centre-of-gravity and moment-of-inertia prediction, Factor of safety, Micro-Machined Electro-Mechanical Systems(MEMS), Manufacturing processes, Airframe material alternative, Aerodynamic heating prediction, Insulation trades, Insulation material alternatives, Structure design, Seeker dome materials, Thermal stress, Localized aerodynamic heating

Flight Performance Considerations In Tactical Missile Design: Flight performance envelope, Equations of motion modeling, Driving parameters for flight performance, Cruise flight performance, Steady state flight, Flight trajectory shaping, Turn radius, Coast flight performance, Boost flight performance, Intercept lead angle and velocity, Comparison with performance requirements

UNIT-IV:

Measures Of Merit And Launch Platform Integration: Robustness, Warhead lethality, Miss distance, Carriage and launch observables, Other survivability considerations, Reliability, Cost, Launch platform integration

Sizing Examples: Air-to-Air range requirements, Wing sizing for maneuverability, Weight and miss distance harmonization, Ramjet missile range robustness, Ramjet propulsion/fuel alternatives, Ramjet missile surface impact velocity, Computer-Aided sizing for conceptual design, Verification process

UNIT-V:

Development Process, Summary And Lessons Learned: Development Process:Technology Assessment/Roadmap, Phases of Development/Design maturity, Tactical-missile follow-on programs, Subsystem integration, Examples of technology development, Examples of State-of-the-Art advancement, New technologies for tactical missiles; Summary and Lessons Learned: Iterate-the-System-of-Systems Analysis, Exploit diverse skills, Apply creative skills, Identify high-payoff measures of merit, Start with a good baseline design, Conduct balanced tradeoffs, Evaluate a broad range of alternatives, Refine the design, Evaluate technology risk, Maintain real-time documentation, Develop good documentation, Utilize group skills, Balance the tradeoff of importance versus priority, Iterate the configuration design, Configuration sizing conceptual design criteria

TEXT BOOK

1. *Tactical Missile Design,* Eugene L. Freeman, First Edition, AIAA Education Series, 2001

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

HIGH ANGLE OF ATTACK AERODYNAMICS (Elective-IV)

Aim:

The students will be given thorough understanding of high angle attack aerodynamics and related flow behavior.

Outcome:

The student will be able to describe and solve high angle of attack aero dynamics problems mathematically.

UNIT-I:

Description Of Flows At High Angles Of Attack: Introduction, Finite lifting wing of medium and high aspect ratio at low subsonic speeds, Low aspect ratio rectangular wing at low subsonic speeds, Slender delta type wings, Flow over elongated slender bodies, Aircraft type configurations, Vortex breakdown, Non-steady aerodynamics at high angles of attack on slender configurations, Effect of separation at **high angles of attack in hypersonic flows**

UNIT-II:

Topology Of Separating And Reattaching Vortical Flows: Equations for vortical flows, Topological concepts for the analysis of vortical flows,

Linear Aerodynamics Of Wings And Bodies: Equations for potential subsonic flows, Equations for the lifting wing at low speeds, Linear panel methods for the calculation of the subsonic aerodynamic coefficients for wings and bodies, Low and higher order linear panel methods for subsonic and supersonic flows, Comparison of various panel methods

UNIT-III:

Vortex Flows And The Rolled Up Vortex Wake: Vortex core of the rolled up wake, Rolled up tip vortices, Rolling up of vortex wake behind wings, Bursting of rolled up vortices

Nonlinear Aerodynamics Of Wings And Bodies At High Angles Of Attack: Analytical and semi-empirical methods for calculations of the non-linear aerodynamic characteristics

UNIT-IV:

Nonlinear Panel Methods For Aircraft And Missile Configurationsat High Angles Of Attack: Nonlinear Vortex Lattice Method (NVLM) for subsonic flows, Free vortex sheet method for subsonic flows, NVLM for supersonic flows

Solutions Of Euler Equations For Flows Over Configurations At High Angles Of Attack: Euler equations, Numerical methods of solution of the Euler equations: Grid generation methods, Finite volume methods, Finite difference methods, finite element methods, multigrid calculations with Cartesian grids and local refinements, Euler computations on three-dimensional configurations at high angles of attack

UNIT-V:

Solutions Of Navier-Stokes Equations For Flows Over Configurations At High Angkes Of Attack: Formulation of the Navier-Stokes equations, Numerical methods for solutions of Navier-Stokes equations, Method of solution of the thin layer equations, Grid topology, boundary and initial conditions, Solutions of Navier-Stokes equations for flows in three-dimensional configurations at high angles of attack

TEXT BOOK

1. *High Angle of Attack Aerodynamics-Subsonic, Transonic, and Super sonic Flows*, Josef Rom, Springer-Verlag, 1992

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M. Tech – I Year – II Sem. Aerospace Engg.

OPTIMAL CONTROL
(ELECTIVE-IV)

Aim:
Advance optimization principles are taught in the subject.

Outcome:
The student will be able to apply optimization techniques in the domain of aerospace engineering.

UNIT-I:
Introduction To Optimization: Classification of systems, Parameter Optimization: Distance problem, General parameter optimization problem, Optimal Control Theory: Distance problem, Acceleration problem, Navigation problem, General optimal control problem, Conversion of an optimal control problem into a parameter optimization problem, Necessary conditions and sufficient conditions

UNIT-II:
Parameter Optimization-I: Unconstrained Minimization: Taylor series and differentials, Function of one, two and n independent variables; Constrained Minimization-Equality Constraints: Function of two constrained variables-Direct and Lagrange Multiplier approaches, Distance problem, Function of n constrained variables
Parameter Optimization-II: Constrained Minimization-Inequality Constraints: Boundary minimal points, Introduction to slack variables, Function of two variables, Eliminating bounded variables, Examples of linear programming, General problem, Minimization Using Matrix Notation: Matrix algebra, Matrix calculus, Function of n independent variables, Function of n constrained variables

UNIT-III:
Differentials in Optimal Control and Controllability: Differentials in Optimal Control: Standard optimal control problem, Differential of the state equation, Relation between δ and d, Differential of the final condition, Differential of the integral,: Controllability: Fixed final time, Solution of the linear equation, controllability condition, Controllability-free final time, Navigation problem
Fixed Final Time- First Differential, Tests for A Minimum and Second Differential: Fixed Final Time-First Differential: First differential conditions-with and without final state constraints, First integral, Acceleration problem, Navigation problem, Minimum distance on a sphere, Fixed Final Time-Tests for a Minimum: Weierstrass condition, Legendre-Clebsch condition; Fixed Final Time-Second Differential: Second differential, Legendre-Clebsch condition, Neighboring optimal paths, Neighboring optimal paths on a sphere, Second differential condition, Acceleration problem, Navigation problem, Minimum distance on a sphere, Minimum distance between two points on a sphere, Other sufficient conditions

UNIT-IV:
Free Final Time, Free Initial Time and States: Free Final Time: First differential conditions, Tests for a minimum, second differential, neighboring optimal paths, second differential conditions, Distance and navigation problems, Free Initial Time and States: Problem statement, First differential conditions, Tests for a minimum, Second differential conditions, Minimum distance from a parabola and a line, Parameters as states, Navigation problem

UNIT-V:
Control Discontinuities and Path Constraints : Control Discontinuities Problem statement, First differential conditions, Tests for s minimum, Second differential, Neighboring optimal path, Second differential conditions, Supersonic airfoil of minimum pressure drag; Path Constraints: Integral constraint, State equality constraint, Control inequality constraint, Acceleration problem, State inequality constraint
Approximate Solutions of Optimal Control Problems: Optimal control problem with a small parameter, Application to a particular problem, Application to a general problem, Solution by the sweep method, Navigation problem

TEXT BOOK

1. *Optimal Control Theory for Applications,* David G. Hull, Springer-Verlag, 2003, ISBN: 0-387-40070-2

REFERENCE BOOK

1. *Applied Optimal Control-Optimization, estimation and Control,* Arthur E. Bryson, Jr and Yu-Chi Ho, Taylor & Francis, 1975, ISBN 10: 0891162285

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD

M. Tech – I Year – II Sem. Aerospace Engg.

DIGITAL SIMULATION LAB-II

Aim:

To familiarize the student with analysis of aircraft components in virtual environment.

Outcome:

The student shall be able to take up the knowledge in the design and modeling of aircraft structures.

I Software development for the following using finite element methods:

- Thin walled beams
- Plate bending
- Beams analysis
- Trusses analysis
- Thin shells analysis

II Aerospace Structural Analysis using ANSYS

- Structural analysis of aircraft wing
- Structural analysis of aircraft wing (Composite material)
- Analysis of fuselage
- Rocket motor case analysis
- Structural and thermal analysis of rocket nozzles
- Fractural mechanics of crack propagation

III. Simulation Experiments in Dynamics and Control using MATLAB and Simulink

- Simulation of Aircraft motion-longitudinal dynamics, lateral dynamics
- Six-degrees-of-freedom simulation of aircraft motion with illustration of F-16 model
- Simulation of reentry vehicle dynamics for ballistic reentry and maneuvering reentry
- Simulation of non-linear control system for controlling roll dynamics of a fighter aircraft
- Simulation of the following relating to satellite attitude dynamics:
  - Torque free rotation of axisymmetric and asymmetric spacecraft
  - Attitude maneuvers of spin-stabilized spacecraft

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3. *Modern Control Design with MATLAB and Simulink,* A. Tewari, Wiley, 2002