MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

(Autonomous Institution – UGC, Govt. of India)

Sponsored by CMR Educational Society

(Affiliated to JNTU, Hyderabad, Approved by AICTE - Accredited by NBA & NAAC – 'A' Grade - ISO 9001:2008 Certified)
Maisammaguda, Dhulapally (PostVia Hakimpet), Secunderabad –500100, Telangana State,India.

Contact Number: 040-23792146/64634237, E-Mail ID: mrcet2004@gmail.com,website:www.mrcet.ac.in

MASTER OF TECHNOLOGY AEROSPACE ENGINEERING

DEPARTMENT OF AERONAUTICAL ENGINEERING

COURSE STRUCTURE AND SYLLABUS

(Batches admitted from the academic year 2024 - 2025)

Note: The regulations hereunder are subject to amendments as may be made by the Academic Council of the College from time to time. Any or all such amendments will be effective from such date and to such batches of candidates (including those already pursuing the program) as may be decided by the Academic Council.

PRELIMINARY DEFINITIONS AND NOMENCLATURES

" Autonomous Institution /College" means an institution/college designated as autonomous institute / college by University Grants Commission (UGC), as per the UGC Autonomous College Statutes.

- "Academic Autonomy" means freedom to a college in all aspects of conducting its academic programs, granted by the University for promoting excellence.
- "Commission" means University Grants Commission.
- "AICTE" means All India Council for Technical Education.
- "University" the Jawaharlal Nehru Technological University, Hyderabad.
- "College" means Malla Reddy College of Engineering & Technology, Secunderabad unless indicated otherwise by the context.
- "Program" means: Master of Technology (M.Tech) degree program PG Degree Program: M.Tech
- "Branch" means specialization in a program like M.Tech degree program in Aeronautical Engineering, M.Tech degree program in Computer Science and Engineering etc.
- "Course" or "Subject" means a theory or practical subject, identified by its course – number and course-title, which is normally studied in a semester.
- T–Tutorial, P–Practical, D–Drawing, L-Theory, C-Credits

FOREWORD

The autonomy is conferred on Malla Reddy College of Engineering & Technology (MRCET) by UGC based on its performance as well as future commitment and competency to impart quality education. It is a mark of its ability to function independently in accordance with the set norms of the monitoring bodies like UGC and AICTE. It reflects the confidence of the UGC in the autonomous institution to uphold and maintain standards itexpects to deliver on its own behalf and thus awards degrees on behalf of the college. Thus, an autonomous institution is given the freedom to have its own curriculum, examination system and monitoring mechanism, independent of the affiliating University but under its observance.

Malla Reddy College of Engineering & Technology (MRCET) is proud to win the credence of all the above bodies monitoring the quality in education and has gladly accepted the responsibility of sustaining, and also improving upon the values and beliefs for which it has been striving for more than a decade in reaching its present standing in the arena of contemporary technical education. As a follow up, statutory bodies like Academic Council and Boards of Studies are constituted with the guidance of the Governing Body of the College and recommendations of the JNTU Hyderabad to frame the regulations, course structure and syllabi under autonomous status.

The autonomous regulations, course structure and syllabi have been prepared after prolonged and detailed interaction with several experts drawn from academics, industry and research, in accordance with the vision and mission of the college which reflects the mindset of the institution in order to produce quality engineering graduates to the society.

All the faculty, parents and students are requested to go through all the rules and regulations carefully. Any clarifications, if needed, are to be sought at appropriate time and with principal of the college, without presumptions, to avoid unwanted subsequent inconveniences and embarrassments. The Cooperation of all the stake holders is sought for the successful implementation of the autonomous system in the larger interests of the institution and brighter prospects of engineering graduates.

"A thought beyond the horizons of success committed for educational excellence"

PRINCIPAL

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

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Maisammaguda, Dhulapally (Post Via Hakimpet), Secunderabad – 500100, Telangana State, India.
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VISION

- To establish a pedestal for the integral innovation, team spirit, originality and competence in the students, expose them to face the global challenges and become technology leaders of Indian vision of modern society.

MISSION

- Tobecome a model institution inthe fields of Engineering, Technology and Management.
- Toimpart holistic education to the students to render them as industry ready engineers.
- Toensure synchronization of MRCET ideologies with challenging demands of International Pioneering Organizations.

QUALITY POLICY

- To implement best practices in Teaching and Learning process for both UG and PG courses meticulously.
- To provide state of art infrastructure and expertise to impart the quality education.
- To groom the students to become intellectually creative and professionally competitive.
- To channelize the activities and tune them in heights of commitment and sincerity, the requisites to claim the never-ending ladder of SUCCESS year after year.

For more information: www.mrcet.ac.in

M.TECH – AEROSPACE ENGINEERING

COURSE STRUCTURE & SYLLABUS

I Year I Semester

S.NO.	SUBJECT CODE	SUBJECT	L	T/P/D	C	MAX MARKS	
						INT	EXT
1	R24D7601	Aerodynamics of Flight Vehicles	3	-	3	30	70
2	R24D7602	Engineering Analysis of Flight Vehicles	3	-	3	30	70
3	R24D7605 R24D7606 R24D7607	Program Elective-I 1) Fundamentals of Aerospace Engineering* 2) Air-breathing Propulsion and Design 3) Flight Navigation and surveillance systems	3	-	3	30	70
4	R24D7608 R24D7609 R24D7610	Program Elective-II 1) Modeling and Simulation of Fluid Flows 2) Continuum Mechanics 3) Rotorcraft Aerodynamics	3	-	3	30	70
5	R24DHS53	Research Methodology	3	-	3	30	70
6	R24D7681	Aerodynamics simulation Lab		3	2	30	70
7	R24D7682	Digital Simulation – I Lab		3	2	30	70
8	R24DHS54	Audit Course I - Value Education	2	-	-	50	-
Total			17	6	19	260	490

*Audit course: Non-credit course, 50% of scoring is required for the award of the degree

NOTE: *Fundamentals of Aerospace Engineering

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

I Year II Semester

S.NO.	SUBJECT CODE	SUBJECT	L	T/P/D	C	MAX MARKS	
						INT	EXT
1	R24D7603	Aircraft Control and Simulation	3	-	3	30	70
2	R24D7604	Rocket and Missile Technology	3	-	3	30	70
3	R24D7611 R24D7612 R24D7613	Program Elective-III 1) High Angle of Attack Aerodynamics 2) Composite materials and structures 3) Computational Structural Analysis	3	-	3	30	70
4	R24D7614 R24D7615 R24D7616	Program Elective-IV 1) Tactical Missile Design 2) Aerospace Sensors and Measurement Systems 3) Aero elasticity	3	-	3	30	70
5	R24D7691	Mini Project	3	-	3	30	70
6	R24D7683	Flight Control Lab	-	3	2	30	70
7	R24D7684	Digital simulation – II Lab	-	3	2	30	70
8	R24DHS55	Audit Course II - English for Research Paper Writing	2	-	-	50	
Total			17	6	19	260	490

*Audit course: Non-credit course, 50% of scoring is required for the award of the degree

II Year I Semester

S.NO.	SUBJECT CODE	SUBJECT	L	T/P/D	C	MAX MARKS	
						INT	EXT
1	R24D7617 R24D7618 R24D7619	Program Elective-V 1) Space Transportation Systems 2) Computational Approaches to Aerospace Vehicle Design 3) Hypersonic Aerodynamics	3	-	3	30	70
2	OE	Open Elective	3	-	3	30	70
3	R24D7692	Dissertation Phase – I/Industrial Project	-	-	8	100	-
Total			6	-	14	160	140

II Year II Semester

S.NO.	SUBJECT CODE	SUBJECT	L	T/P/D	C	MAX MARKS	
						INT	EXT
3	R24D7693	Dissertation Phase – II	-	-	14	100	200
Total			-	-	14	100	200

OPEN ELECTIVE	
Subject Code	Subject Name
R24DME51	Non-Conventional Energy Sources
R24DME52	Industrial Safety
R24DME53	Operations Research
R24DHS51	Business Analytics
R24DCS51	Scripting languages
R24DAE51	Mathematical Modeling & Techniques
R24DEC51	Embedded system programming

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

	L	T/P/D	C
I Year M. Tech, ASP-I SEM	**3**	**-**	**3**

(R24D7601) AERODYNAMICS OF FLIGHT VEHICLES

OBJECTIVES:

The course enables the students to

- Ability to find aerodynamic characteristics of airfoils.
- Understand the aerodynamics of wing to minimize drag.
- Know the effects of wing body combination and compressible flows.
- Analyze the turbulent flow characteristics.
- Understand the unsteady flow effects in aerodynamic characteristics.

UNIT-I: REVISION OF BASICS LEARNT AT UNDER GRADUATE LEVEL IN BRIEF

AERODYNAMIC CHARACTERISTICS OF AIRFOILS: Vortex sheet, Vortex sheet in thin-airfoil theory, Planar wing, Properties of symmetrical airfoil, Properties of cambered 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.

UNIT-III: COMPRESSIBLE FLOWS

One dimensional flow governing equations, Oblique shock waves, effect of Θ - β - M relations on shock solutions. Expansion waves, Prandtl – Meyer Expansion. Shock Expansion theory. Area-Mach relation, Isentropic flow through Convergent – Divergent nozzles. Method of characteristics and applications.

UNIT-IV: 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 ofenergy 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-V: UNSTEADY AERODYNAMICS

Unsteady lifting force coefficient, Unsteady aerodynamics of slender wings, Compressible Unsteady aerodynamics, Equations of motion, Boundary condition, moving coordinate system, Navier Stoke equations, Aerodynamic forces and moments, Turbulence modelling, Numerical Problems

TEXT BOOKS

1. Fundamental of Aerodynamics, Anderson, J.D., Mc Graw-Hill International third edition Singapore-2001.
2. *Foundations of Aerodynamics*: Bases of Aerodynamic Design, Arnold M. Kuethe and Chuen- Yen Chow, John Wiley&Sons, Inc., FifthEdition, 1997, ISBN: 978-0-471-12919-6
3. *Fundamentals of Modern Unsteady Aerodynamics*, Gulcat, Ulgen, Springer, Publications, ISBN 978-3-642-14761-6

Course Outcomes:

- Student can able to apply thin airfoil theory to find aerodynamic characteristics of airfoil.
- Applying analytical methods to find aerodynamic characteristics of wing.
- Design of wing body combinations.
- Study the effects of turbulent flows using experimental methods.
- Understand the complex problems due to unsteady flows over wings.

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

I Year M. Tech, ASP-I SEM

L	T/P/D	C
3	-	3

(R24D7602) ENGINEERING ANALYSIS OF FLIGHT VEHICLES

OBJECTIVES:

- Analyze the key factors affecting vehicles configuration.
- Understand the basic concepts of gravitational terms in the equations of motion.
- Explain the concepts of static stability, trim static performance.
- Analyze dynamic performance of spacecraft with respect to non-rotating planets.
- To teach students about the fundamentals of vehicle flight in space

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, Principal axes, Stability axes, Aerodynamic axes, Orientation of the vehicle relative to the ground; flight path determination, Gravitational terms in the equations of motion, The state vector, Equations of motion; Aerodynamic Approximations; stability derivatives; Estimation of stability derivatives: Longitudinal.

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

OUTCOMES:

- The student will be in a position to take up some specific tasks in flight vehicle engineering analysis.
- Develop equations that characterize aircraft equations of motion
- Able to apply basic principles of stability
- Develop equations that characterize dynamic performance of space craft with respect to non-rotating planets
- Develop the equation of motion of launch vehicles with respect to a rotating planet

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

	L	T/P/D	C
I Year M. Tech, ASP-I SEM	**3**	**-**	**3**

(R24D7605) FUNDAMENTALS OF AEROSPACE ENGINEERING*
(PROGRAM ELECTIVE-I)

OBJECTIVES:

- Understand basic principles of aviation and the history of space vehicles.
- Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil and study the incompressible over finite wings
- Understand the governing laws of fluid flow
- Acquire the basic knowledge of airplane performance, stability and control
- Understand the basics of space propulsion, spacecrafts and their orbits.

UNIT-I: INTRODUCTION TO AEROSPACE ENGINEERING

Brief history of Aeronautics, Anatomy of the Airplane, Anatomy of a Space Vehicle, The Nature of Aerodynamic forces and dimensional analysis; Theory and experiment: wind tunnels, Atmosphere: Properties of U.S. standard atmosphere, Definitions of altitude, Flight Instruments.

UNIT-II: Aircraft Aerodynamics

Review of Governing equations, Speed of sound, Compressible flow equations, Airfoil pressure distribution, Lift, drag, moment, Slope of finite wing lift curve, Additional effects of wing vortices, Search for reduced induced drag, Effect of turbulent boundary layer on separation; Parasite drag, drag due to lift, Importance of aspect ratio; Prediction of drag divergence Mach number, Critical Mach number, Wave drag, Sweptback wings, Total drag, Leading and trailing edge devices.

UNIT-III: 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-IV: AIRCRAFT PROPULSION AND AIRCRAFT STRUCTURES

Propulsion: Piston engines, Gas turbines, Speed limitations of gas turbines: ramjets, Propellers, Overall propulsion efficiency, Propulsion- airframe integration; Aircraft structures: Importance of structural weight and integrity, Development of aircraft structures, Importance of fatigue, Materials, Loads, Weight estimation.

UNIT – V: Space Mechanics

Configuration of Rocket and types, Rocket engines, Rocket motor performance, Rocket trajectories, Multistage rockets, Escape velocity, Circular orbital or satellite velocity, Elliptical orbits, Orbital maneuvers.

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

OUTCOME:

- The non-B. Tech aeronautical engineering students will gain insights to various aspects of aircraft structures flight systems and flight mechanics
- Evaluate the effect of fluid properties.
- Utilize the concepts of compressible flow and shock phenomenon
- Apply knowledge of oblique shock and expansion wave formation.
- Become proficient in evaluating basic aerodynamic and flight performance characteristics of aircraft.

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	L	T/P/D	C
I Year M. Tech, ASP-I SEM	**3**	**-**	**3**

(R24D7606) AIR-BREATHING PROPULSION AND DESIGN

(PROGRAM ELECTIVE-I)

UNIT-I: FUNDAMENTALS OF JET PROPULSION

Aircraft Propulsion, Thermodynamic relations and cycles involved, Classification of Air breathing Engines, Ideal and Real Cycle Analysis - Turbojet and Turbofan, Effects of Altitude, Mach number, Aircraft Performance and Engine Performance analysis, Aircraft Engine Design, Methods employed for Thrust Augmentation and Jet Engine Noise suppression.

UNIT-II: INLETS AND NOZZLES

Types of Inlets, Combined Area Changes and Friction, Supersonic Inlet Design Considerations, Engine Starting, Effect of Additive Drag, Types of nozzles, Performance Map, Non-ideal equations for Various Nozzles, Effects of Pressure Ratios on Engine Performance, Performance Maps, Methods and advantages in reversing the Thrust, Types of Thrust Vectoring.

COMBUSTION CHAMBER

Classification of combustion chamber, Process of Combustion, factors affecting combustion, Chemical Kinetics, Properties of various fuels used in aviation, Flame Stabilization, Ignition and Engine Starting, Adiabatic Flame Temperature, Pressure Losses, Design and Optimization, Performance Maps.

UNIT-III: COMPRESSORS AND TURBINES

Classification of Compressors, Euler's Turbo-Machinery Equations, components of axial flow compressor, stage, Velocity Triangles, Single-Stage Energy Analysis, Variable Stators, Radial Equilibrium and Streamline Analysis Method; Centrifugal Compressors- Geometry, Velocity triangles, 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

Working principle of Ramjet engine, Combustors for liquid fuel ramjet engines, Combustion Instability and its Suppression, Solid fuel Ramjet Engines, Test bed of Ramjet engine, Advancements in 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. Problems related to combustion, CFD techniques and guide lines required in designing and development of combustor employed in ramjets.

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 tube and shock Tunnel, Hypersonic wind 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 MATCHIN G 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. Gas Turbine theory, Cohen H., Rogers G.F.C, Saravana mutto H., Longman Publication, 4th Edition, 2003
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 Air breathing Propulsion, William H. Heiser, David T.Pratt, AIAA Education Series, 1st Edition, 1994

REFERENCE BOOK

1. Gas Tables, Third edition E. Radha Krishnan, University press.
2. Fundamentals of Jet Propulsion with applications, Ronald D. Flack, Cambridge University Press, 1st Edition, 2005.

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	L	T/P/D	C
I Year M. Tech, ASP-I SEM	**3**	**-**	**3**

(R24D7607) FLIGHT NAVIGATION AND SURVEILLANCE SYSTEMS

(PROGRAM ELECTIVE-I)

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 SYSTEMS

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, Automaticlanding 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, Non-inertial GPS multisensory 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

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(R24D7608) MODELING AND SIMULATION OF FLUID FLOWS

(PROGRAM ELECTIVE-II)

Course Objectives:

The course should enable the students to learn:

- Understanding the methodology for mathematical modeling of fluid flows.
- Understand the physics of mathematical equations governing aerodynamic flows.
- Understand various numerical methods to obtain solutions for the convective terms in NS equations.
- Understand various numerical methods to obtain solutions for the time derivative terms in NS equations.

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, 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, 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.

UNIT IV: **NUMERICAL SOLUTIONS FOR CONVECTIVE TERMS**

Euler equations: Flux approach, Lax-Wendroff method, basic principles of upwind schemes, flux vector splitting, Steger Warming flux vector splitting, Van Leer flux vector splitting, Upwind reconstruction, evolution, Godunov's first order upwind method, Roe's first order upwind method.

UNIT V: TIME INTEGRATION METHODS FOR SPACE DISCRETIZED EQUATIONS

Stability of solution, explicit methods, FTFS, FTCS, FTBS, Leapfrog method, Laxmethod. Implicit methods: Euler's FTCS, Crank Nicolson method, description of Lax- Wendroff scheme, McCormack two step predictor-corrector method, description of time split methods, approximate factorization schemes.

TEXT BOOK

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

REFERENCE BOOKS

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.

COURSE OUTCOMES

Upon completion of this course, the student will be able to

- Solve differential equations governing fluid flow problems.
- The student will demonstrate an ability to recognize the type of fluid flow that is occurring in a particular physical system and to use the appropriate model equations to investigate the flow.
- Generation of grid according to geometry of flow and complexity of flow.
- The student will able to select appropriate discretization method to solve given problem.
- Application of CFD techniques for aerospace problems.

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(R24D7609) CONTINUUM MECHANICS

(PROGRAM ELECTIVE-II)

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, Non ion 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, ElsevierInc, 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

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(R24D7610) ROTORCRAFT AERODYNAMICS

(PROGRAM ELECTIVE-II)

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 onairfoil 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-varyingvelocity

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

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(R24DHS53) RESEARCH METHODOLOGY

Course Objectives:

- To familiarize the meaning, objectives and sources of research
- To acquaint the student with the importance and methods of literature review/research ethics
- To impart the knowledge of data collection and analysis of data
- To understand the procedure for Hypothesis testing and writing Research proposals

UNIT - I

Introduction: Research objective and motivation, Types of research, Research approaches, Significance, Research method vs. methodology, Research process.

UNIT - II

Formulating a research problem: Literature review, Formulation of objectives, Establishing Operational definitions, identifying variables, constructing hypotheses.

UNIT - III

Research design and Data Collection: Need and Characteristics, Types of research design, Principles of Experimental research design, Method of data collection, Ethical issues in collecting data.

UNIT - IV

Sampling and Analysis of data: Need of Sampling, Sampling distributions, Central limit theorem, Estimation: mean and variance, Selection of sample size Statistics in research, Measures of Central tendency, Dispersion, asymmetry and relationships, Correlation and Regression analysis, Displaying data

UNIT - V

Hypothesis Testing: Procedure, Hypothesis testing for difference in mean, variance limitations, Chi-square test, Analysis of variance (ANOVA), Basic principles and techniques of writing a Research Proposal

Text Books:

1. R. C. Kothari, Research Methodology: Methods and Techniques, 2nd edition, New Age International Publisher, 2009

2. Ranjit Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 2nd Edition, SAGE, 2005

References:

1. Trochim, William M. The Research Methods Knowledge Base, 2nd Edition. Internet WWW page, at URL: <http://www.socialresearchmethods.net/kb/>

2. (Electronic Version): StatSoft, Inc. (2012). Electronic Statistics Textbook. Tulsa, OK: StatSoft. WEB: http://www.statsoft.com/textbook/.(Printed Version): Hill, T. & Lewicki, P. (2007). STATISTICS: Methods and Applications. StatSoft, Tulsa, OK.

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(R24D7681) AERODYNAMICS SIMULATION LAB

Objectives:

The course should enable the students to:

1. Learn the programming language to solve problems related to modeling, analysis and design of aerospace vehicle and systems.
2. Introduction to programming language
3. Development of numerical solver code to generate basic potential flows: source, sink and doublet.
4. Development of potential flow solver code to simulate flow over cylinder with source -panels.
5. Development of potential flow solver code to simulate flow over an airfoil with source-panels and calculate lift coefficient.
6. Program to analyze aerodynamic characteristics of wing.
7. Program to find critical Mach number of airfoil.
8. Program to analyze flow across shock waves.
9. Program to analyze flow across expansion waves.
10. Program to analyze flow through convergent and divergent nozzle.
11. Program to analyze the performance of aircraft.
12. Program to design contour of nozzle.

EQUIPMENT NEEDED

1. **Computers**: Core 2 duo processor with 1 GB RAM
2. **Software:** MATLAB or PYTHON or SCILAB or equivalent software

REFERENCE BOOKS

1. MATLAB an Introduction with Applications Fifth Edition AMOS GILAT by WILEY Publications
2. Programming in SCI lab by VINU V DAS NEW AGE INTERNATIONAL PUBLICATIONS
3. Control system tool box in MATLAB, User's Guide.
4. Fundamentals of Aerodynamics by John D Anderson

Outcomes:

- The student should be able to Model and analyze aerodynamic problems using computer software (MATLAB or others).
- The student able to understand programming language and its application.
- Evaluation of commercial software with own code development.

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(R24D7682) DIGITAL SIMULATION - I LAB

1. SOFTWARE DEVELOPMEN T FOR SIMULATION OF FLUID FLOWS

- Generation of structured grids for flow analysis
- Generation of unstructured grid for flow analysis
- Solution of Burgers equation using explicit MacCormack method
- Blasius solution for laminar boundary layer over a flat

2. FLOW SIMULATION

- Simulation of Flow past airfoils at different angle of attack.
- Simulation of Flow past tapered wings at subsonic speeds.
- Simulation of Compressible flow in convergent -divergent nozzle
- Simulation of flow in supersonic intake.
- Simulation of compressible flow in a compressor
- Simulation of fuel-air mixing in supersonic combustion.
- Simulation of unsteady flow over flapping wing
- Simulation of reentry vehicle at hypersonic speeds.

REFERENCES

1. BasicMATLAB, Simulink, and StateFlow, Richard Colgren, AIAAEducationSeries, 2007
2. Computational Fluid Mechanics and Heat Transfer, Second Edition, John C. Tannehill, Dale A. Anderson, Richard H. Pletcher, Taylor&Francis Publication, 1997.
3. Computational FluidDynamics,T. J. Chung, Cambridge UniversityPress, 2002

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(R24DHS54) VALUE EDUCATION
(Audit Course I)

UNIT I: Values and self-development

Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non - moral valuation. Standards and principles, Value judgements

UNIT II: Importance of cultivation of values

Sense of duty, Devotion, Self-reliance, Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity. Power of faith, National Unity, Patriotism, Love for nature, Discipline

UNIT III: Personality and Behavior Development

Soul and Scientific attitude, Positive Thinking, Integrity and discipline, Punctuality, Love and Kindness, avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth, Aware of self-destructive habits, Association and Cooperation, doing best for saving nature

UNIT IV:

Character and Competence

Holy books vs Blind faith, Self-management and good health, Science of reincarnation, Equality, Nonviolence, Humility, Role of Women, all religions and same message, mind your Mind, Self- control, Honesty, Studying effectively

TEXT BOOKS:

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

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(R24D7603) AIRCRAFT CONTROL AND SIMULATION

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, LinearModels 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, Feedback control, Aircraft dynamic behavior.

UNIT-III: AIRCRAFT DYNAMICS AND CLASSICAL CONTROL DESIGN

Aircraft Rigid Body Modes, The Handling Qualities Requirements, Stability Augmentation Systems, control augmentation system, auto pilots and 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.

DIGITAL CONTROL

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

TEXT BOOK

1. Aircraft Control and Simulation, BrianL. Stevensand FrankL. Lewis, John Wiley&Sons, 2003

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(R24D7604) ROCKET AND MISSILE TECHNOLOGY

OBJECTIVES:

The course should enable the students to:

- Describe the basic understanding of technologies used for Rockets and Missiles
- Understand the various combustion processes that take place in a solid rocket motor, liquid rocket engine and the hybrid rocket motor
- Comprehend the basic requirements of the rocket test facilities
- To familiarize the various materials used for the construction of rockets and missiles
- Construct a knowledge base on futuristic propulsion techniques.

UNIT-I: INTRODUCTION

Rockets and military missiles – Classification, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements Performance measures, design, construction, operation-similarities and differences, Some famous space launch vehicles and strategic missiles.

UNIT-II: SOLID, LIQIUD AND HYBRID PROPULSION SYSTEMS

Solid propellant rocket motors-Principal features, applications, propellant types, composition, properties and performance. Propellant grain - Desirable properties, grain configuration and preparation. Combustion instabilities.

Liquid propellants –Types, composition, properties. performance and storage. Propellant tank arrangements. Various feed systems and injectors for liquid propellant rockets. Control of engine starting and thrust build up. Geysering effect in cryogenic rocket engines.

Hybrid propellant rockets: Hybrid rocket operation and hybrid rocket characteristics.

UNIT-III: AERODYNAMICS AND CONTROL OF ROCKETS AND MISSILES

Airframe components of rockets and missiles. Forces acting on a missile while passing through atmosphere, Method of describing aerodynamic forces and moments, Lateral aerodynamic moment, Lateral damping moment, Longitudinal moment of a rocket, Lift and Drag forces, drag estimation, Body up wash and downwash in missiles, Rocket dispersion. Re-entry body design considerations

Attitude Control- Rocket thrust vector control, methods of thrust vector control for solid and liquid propulsion systems, thrust magnitude control. thrust termination; stage separation dynamics, separation techniques

UNIT-IV: MATERIALS AND ROCKET TESTING

Criteria for selection of materials for rockets and missiles- requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels.

Ground testing and flight testing-types of tests, test facilities and safety measures, monitoring and control of toxic materials, instrumentation and data management. Ground testing, flight testing, trajectory monitoring, post-accident procedures. Description of a

typical space vehicle launching procedure.

UNIT-V ADVANCED PROPULSION TECHNIQUES

Electric rocket propulsion– types of electric propulsion techniques - Ion propulsion – Nuclear rocket – comparison of performance of these propulsion systems with chemical rocket propulsion systems –future applications of electric propulsion systems - Solar sail

TEXT BOOKS

1. Sutton, GP. andBiblarz, ., Rocket Propulsion Elements,7th edition, Wiley-Interscience, 2000.
2. Cornelisse, J.W., Schoyer H.F.R. and Wakker. K.F.,Rocket propulsion and space flight dynamics ,pitman 1979
3. Turner, M.J.L., Rocket and Spacecraft Propulsion, springer ,2001
4. Hill, PG. and Peterson, CR, Mechanics and Thermodynamics of propulsion, 2nd edition, Addison Wesley ,1992

REFERNCE BOOKS

1. Anderson JD., Introduction to flight 5th edition, Tata McGraw Hill ISBN: 0-07-006082-4
2. James all the world flight vehicles Jones aviation publications London

COURSE OUTCOMES:

Upon the successful completion of the course, students will be able to:

- Understand the basic technologies used for Rockets and Missiles
- Realize the various combustion processes involved in solid, liquid and the hybrid rockets
- Relate the significance, types of test facilities and their associated parameters.
- Select suitable materials for different parts of rockets and missiles prescribed for a specific mission
- Understand the emerging advanced propulsion techniques for futuristic space programs.

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(R24D7611) HIGH ANGLE OF ATTACK AERODYNAMICS

(PROGRAM ELECTIVE-III)

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 break down, 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 andsemiempirical methods for calculations of the non-linear aerodynamic characteristics

UNIT-IV:

Nonlinear Panel Methods for Aircraft and Missile Configurations at 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 Angles 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 highangles of attack

TEXT BOOK

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

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(R24D7612) COMPOSITE MATERIALS AND STRUCTURES

(PROGRAM ELECTIVE-III)

COURSE OBJECTIVES:

1. Study of different composite materials and finding its mechanical strength
2. Fabrication of FRP and other composites by different manufacturing methods
3. Stress analysis of fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
4. Calculation of stresses in the lamina of the laminate using different failure theories
5. Calculation of residual stresses in different types of laminates under thermo-mechanical load using the Classical Laminate Theory.

UNIT-I INTRODUCTION TO COMPOSITE MATERIALS 9

Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments-ceramic fibers-fiber fabrication-natural composite wood, Jute Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites

UNIT- II MANUFACTURING OF COMPOSITES 9

Manufacturing of Polymer Matrix Composites (PMCs)-handlay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM)-,bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs)–hot pressing reaction bonding process-infiltration technique, direct oxidation-interfaces

UNIT-III LAMINA CONSTITUTIVE EQUATIONS 9

Lamina Constitutive Equations: Lamina Assumptions–Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

UNIT-IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES 9

Introduction- Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations– Natural Frequencies

UNIT- V THERMO-STRUCURALANALYSIS 9

Fabrication stresses / Residual stresses in FRP laminated composites-Co-efficient of Thermal

Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's -Stress and Moment Resultants due cooling of the laminates during fabrication-Calculations for thermo-mechanical stresses in FRP laminates Case studies: Implementation of CLT for evaluating residual stresses in the components made with different isotropic layers such as electronic packages etc.

COURSE OUTCOMES: On Completion of the course the student will be able to

1. Calculate for mechanical strength of the composite material
2. Fabricate the FRP and other composites by different manufacturing methods
3. Analyze fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
4. Evaluate the stresses in the lamina of the laminate using different failure theories
5. Analyze thermo-mechanical behavior and evaluate residual stresses in different types of laminates using the Classical Laminate Theory.

REFERENCES:

1. Agarwal BD and Broutman LJ, "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York,1990.
2. Gibson RF, Principles of Composite Material Mechanics, CRC press,4th Edition,2015.
3. Hyer MW and Scott R White, "Stress Analysis of Fiber – Reinforced Composite Materials",McGraw-Hill,1998
4. Issac M Daniel and OriIshai, "Engineering Mechanics of Composite Materials", OxfordUniversityPress-2006,FirstIndian Edition-2007
5. Madhujit Mukhopadhyay,"Mechanics of Composite Materials and Structures", University Press(India)Pvt.Ltd.,Hyderabad,2004(Reprinted 2008)
6. Mallick PK, Fiber – Reinforced Composites: Materials, Manufacturing and Design, CRC Press,

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(R24D7613) COMPUTATIONAL STRUCTURAL ANALYSIS	**3**	**-**	**3**

(PROGRAM ELECTIVE-III)

UNIT I: **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, Iso parametric Quadrilateral and Hexahedron Elements, Plate Bending Elements, Shell Elements, Areas of Analysis, Application of the Galerkin Method.

UNIT- II: **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 Non-spinning 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.

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

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(R24D7614) TACTICAL MISSILE DESIGN
(PROGRAM ELECTIVE-IV)

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 Missile 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 BOOKS

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

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(R24D7615) AEROSPACE SENSORS AND MEASUREMENT SYSTEMS
(PROGRAM ELECTIVE - IV)

Course Objectives:

The course should enable the students in:

1) Understanding various experimental methods to study the fluid flows.
2) Understanding the working principles of various wind tunnels.
3) Understanding the working principles of various sensors and measurement systems used for fluid flow measurements.
4) Understanding the techniques used for visualization of fluid flows.
5) Understanding the working principle of various motion and inertial measuring sensors.

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: **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 a strain gauge, Electrical resistance strain gauges, Strain gauge sensitivity, Stress gauges.

UNIT III: **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), Turbulence Measurements: LDV, Hot wire anemometers, Root Mean Square (RMS), Spectrum;

UNIT IV: **MOTION AND INERTIAL MEASUREMENTS**

Two simple vibration instruments, Principles of seismic instrument, Practical considerations for seismic instruments, Sound 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: **FLOW VISUALIZATION**

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

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 NManik, 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

Course Outcomes:
Upon completion of this course, the student will be able to

1) Develop detailed understanding of various experimental methods to study the fluid flows.
2) Develop understanding the working principles of various wind tunnels.
3) Acquire knowledge about the working principles of various sensors and measurement systems used for fluid flow measurements.
4) Understand the techniques used for visualization of fluid flows.
5) Have complete skills to plan to conduct experiment to understand fluid flows on their own.

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(R24D7616) AEROELASTICITY

(PROGRAM ELECTIVE-IV)

UNIT-I: AEROELASTIC PHENOMENA

Stability versus response problems; The aeroelastic triangle of forces; Aero elasticity in Aircraft Design; Prevention of aero elastic instabilities. Influence and stiffness coefficients. Coupled oscillations.

UNIT-II: DIVERGENCE OF A LIFTING SURFACE

Simple two-dimensional idealizations; Strip theory, Integral equation of the second kind Exact solutions for simple rectangular wings, Semirigid‟ assumption and approximate solutions; Generalized coordinates, successive approximations, numerical approximations using matrix equations.

UNIT-III: STEADY STATE AEROLASTIC PROBLEMS

Loss and reversal of aileron control, critical aileron reversal speed, aileron efficiency, semi rigid theory and successive approximations, lift distribution, rigid and elastic wings.
Tail efficiency, effect of elastic deformation on static longitudinal stability.

UNIT-IV: FLUTTER PHENOMENON

Non-dimensional parameters, stiffness criteria, dynamic mass balancing, dimensional similarity; Flutter analysis, two dimensional thin airfoils in steady incompressible flow, quasi steady aerodynamic derivatives; Galerkin method for critical flutter speed, stability of disturbed motion, solution of the flutter determinant, methods of determining the critical flutter speeds, flutter prevention and control.

UNIT-V: EXAMPLES OF AEROELASTIC PROBLEMS

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

Text Books:

1. Y.C.Fung, “An Introduction to the Theory of Aero elasticity”, John Wiley & Sons Inc., New York, 2008.
2. E.G. Broadbent, “Elementary Theory of Aero elasticity”, Bun Hill Publications Ltd., 1986.

Reference Books:

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, “Aero elasticity”, Edition Addison Wesley Publishing Co., Inc., 2nd Edition, 1996.
2. R.H. Scanlan and R. Rosenbaum, “Introduction to the study of Aircraft Vibration and Flutter”, Macmillan Co., New York,1981.
3. R. D. Blevins, “Flow Induced Vibrations”, Krieger Pub Co.,2001

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(R24D7683) FLIGHT CONTROL LAB

1. MATLABintroduction, Plottingandgraphics: Plot, logandsemi-logplots, polarplots,Subplots, axis, mesh, contour diagrams, flow diagrams, movies.
2. MATLAB Toolboxes: Continuous transfer functions, root locus, Nichol's chart, Nyquist chart, linear quadraticregulator, state-spacedesign, digital design, Aerospace toolbox; M Cells, Structures and M-files, MEX-files,
3. Standard Simulink libraries, Simulink aerospace blockset, Building Simulink linear models: transfer function modeling in Simulink, zero pole model, state-space model;
4. 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;
5. State flow introduction: Opening, executing, and saving state flow models, constructing a simple state flow model, using a state flow truth table
6. Stability analysis using Root locus, Bode plot techniques.
7. Design of lead, lag and lead –lag compensator for aircraft dynamics.
8. Performance Improvement of Aircraft Dynamics by Pole placement technique.
9. Simulation of Aircraft motion-longitudinal dynamics, lateral dynamics
10. Design of Turn Co-ordination system
11. Design of Observers and Kalman filters
12. Six-degrees-of-freedom simulation of aircraft motion with illustration of F-16 model

References

1. Atmospheric and Space Flight Dynamics, Ashish Tewari, Birkhauser Publication, 2007
2. Modern Control Design with MATLAB and Simulink, A. Tewari

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(R24D7684) DIGITAL SIMULATION-II LAB

Objectives:

1. To obtain an understanding of the fundamental theory of the FEA method;
2. To understand the use of the basic finite elements for structural applications using truss, beam, frame, and plane elements;
3. To gain knowledge about element and mesh selection for a particular structural problem
4. To know the different material influence and their limitation when a particular structure is loading
5. To understand the application and use of the FE method for Aerospace structural and dynamic problems.

I SOFTWARE DEVELOPMENT FOR THE FOLLOWING USING FINITE ELEMENT METHODS

- Thin-walled beams
- Plate bending
- Truss analysis

II AEROSPACE STRUCTURAL ANALYSIS USING ANSYS

- Structural analysis of aircraft wing
- Structural analysis of aircraft landing gear
- Structural analysis of aircraft fuselage
- Vibration analysis of a fiber reinforced composite plate structure
- Structural analysis of aircraft spar with different shapes
- Structural analysis of a Wagner Beam
- Structural and thermal analysis of re-entry vehicle using FGM material

REFERENCES

1. Engineering Analysis with ANSYS Software, Y. Nakasone, S.Yoshimoto, T. A. Stolarski, Elsevier Publication, 2006

Outcomes:

1. The ability to create models for trusses, frames, plate structures, and components using ANSYS general-purpose software;
2. Students gains knowledge about different structural analysis in ANSYS platform like bending, buckling and vibration.
3. To develop a basic understanding of the limitations of the FE method and understand the possible error sources in its use.
4. Major aircraft components analysis design and element selection will be attained
5. Influence of different material on structures and gains basic knowledge of simulink for controlling the airplane motion.

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(R24DHS55) ENGLISH FOR RESEARCH PAPER WRITING (AUDIT COURSE –II)

INTRODUCTION

Writing a research paper is a significant part of any academia. It is a substantial piece of academic writing in which the author does independent investigation into a topic and writes a description of the findings of that study. Research studies are important because these contribute to a scholar's knowledge and also provides solutions to the latest challenges. Writing forces one to think about what he believes and what he wants to communicate. Since good writing skills allow a learner to communicate his message with clarity, an extensive exposure on techniques of writing research paper proves to be an immense value to the students.

OBJECTIVES

1. To enable the students to use linguistic structures to form well-organized texts in research contexts
2. To improve the quality of a composition by using appropriate cohesive devices
3. To enhance the mechanics of writing skills using correct grammar and vocabulary
4. To equip learners with the strategies of error – free writing

SYLLABUS

Unit 1 - Sentence Formation
Word order, structuring paragraphs, Breaking up long sentences

Unit 2 - Cohesive devices
Types of cohesive devices - Anaphoric reference, Cataphoric reference, Exophoric reference
Tense agreement

Unit 3 – Academic Vocabulary
Hedging, Transitions – Additive, Adversative, Causal, Sequential

Unit 4– Grammar for Research Papers
Active & Passive, Punctuation, Articles

Unit 5 – Academic writing
Removing redundancy, Avoiding ambiguity, Paraphrasing, Sample Abstracts for practice, Sample videos

* Exercises apart from the text book shall also be referred for classroom tasks.

REFERENCE BOOKS:

1. English for Writing Research Papers. Adrian Wallwork, edition II, Springer, 2016.
2. Handbook of Technical Writing. James H. Shelton, McGraw Hill, 1994
3. Writing the Research Paper, a handbook. 8th edition, Anthony C. Winkler, Jo Ray Metherell, Wadsworth, 2012

OUTCOMES:

Students will be able to:

1. Write in a clear, coherent, and direct style appropriate for academic research
2. Draft coherent and unified paragraphs with adequate supporting details.
3. Develop the strategy to use lexical terms effectively.
4. Adopt appropriate syntactic and semantic techniques
5. Demonstrate analytical and inferencing skills.
6. Comprehend and employ the various forms of scholarly composition.

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(R24D7617) SPACE TRANSPORTATION SYSTEMS

(PROGRAM ELECTIVE- V)

OBJECTIVES:

- To introduce system engineering and about Indian space transportation systems.
- To understand the factors effecting development of space transportation.
- To get knowledge about Expendable and Reusable launch vehicles.
- Use of optimization strategies to develop future space transportation.
- Importance of team work and planning in project management.

UNIT-I: **SYSTEM ENGINEERING AND INDIAN SPACE TRANSPORTATION SYSTEM DEVELOPMENT**

Introduction, Systems engineering definition, System engineer, Systems engineering cycle, Systems engineering process, Tools and methodologies, Systems analysis, Modelling, and the trade study process, Basic launch vehicle system trade analysis methodology.

Evolution of ISRO, organization and structure of ISRO, Goals, objectives, evolution of Indian carrier rockets-PSLV, GSLV, Chandrayan, Mangalyan

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 missions, U.S. Space Shuttle: 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, Challenges facing manned aerospace planes, Manned reusable systems development programs-Past and Ongoing, Hypersonic wave riders, Importance of vehicle health management, Future reusable space launch vehicles

OPERATIONS AND SUPPORT SYSTEMS

Facility requirements for launch operations, Obstacles to streamlining launch operations, Evolutionary launch operations strategies, 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,

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

OUTCOMES:

- Students can able to know the role system engineering in Indian space transportation systems.
- Students can design infrastructure required for space transportation.
- Identify the operations of Expendable and Reusable launch vehicles and its application.
- Use of optimization strategies to develop future space transportation.
- Implementation of team work and planning in project management with future systems required.

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(R24D7618) COMPUTATIONAL APPROACHES TO AEROSPACE VEHICLE DESIGN

(PROGRAM ELECTIVE – V)

Course objectives:

- To know the historical aerospace design and their limitations
- To obtain the traditional computational technique available to solve the complex structure
- To know the different optimization technique available and their mathematical complexities
- To understand the numerical and approximation methods available to give guidance to solve an aerospace structural problem.
- To attain the knowledge of multidisciplinary optimization

UNIT-I: PRINCIPLES OF AEROSPACE DESIGN

Historical perspective on aerospace design, Traditional manual approaches to design, 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, Lagrange multipliers, Penalty function methods, Combined Lagrangian and penalty function methods, Sequential quadratic programming

UNIT-III: ELEMENTS OF NUMERICAL OPTIMIZATION-II

Meta models and Response surface methods: Global versus local meta models, Meta modeling tools, Simple RSM examples, multi-objective optimization, Pareto set algorithms

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

UNIT-IV: APPROXIMATION CONCEPTS

Local approximations, Multipoint approximations, Black-box modeling, generalized linear models, Sparse approximations techniques, Gaussian process interpolation and regression, Surrogate modeling using variable fidelity models, Reduced basis methods

DESIGN SPACE EXPLORATION-SURROGATE MODELS

Managing surrogate models in optimization: Trust regions, Space mapping approach

UNIT-V: DESIGN IN THE PRESNCE OF UNCERTAIN TY

Uncertainty modeling and representation, Uncertainty propagation, Taguchi methods, Welch -Sacks method, Design for six sigma, Reliability-based optimization

MULTI-DISCIPLINARY O P T I M I Z A T I O N

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

Course outcomes

- The students will understand the development of aerospace design techniques
- Student will understand the difficulties of computational techniques for different structural component.
- Student will gain and improve their mathematical modeling skill in order to solve different structural components.
- Student will know the available optimized technique to solve different applications.
- Student will be able to recognize how to approach a multidisciplinary problem with mathematical constraints.

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(R24D7619) HYPERSONIC AERODYNAMICS

(PROGRAM ELECTIVE - V)

Objectives:

The course should enable the students to:

- Formulate and apply appropriate aerodynamic models to predict the forces on and performance of realistic three-dimensional configurations in hypersonic flows.
- Understand about current aerospace problems like Aerodynamic heating.
- Know about experimental methods for hypersonic flows.

UNIT-I - FUNDAMENTALS OF HYPERSONIC FLOWS AND APPROXIMATIONS

Importance/properties of hypersonic flow-Basic equations boundary conditions for inviscid flow, concept of equilibrium and nonequilibrium flows, transport properties. Basic conservation equations and species continuity equation, hypersonic shock and expansion relations, hypersonic similarity parameters. Newtonian, modified Newtonian.

UNIT-II - HYPERSONIC SMALL DISTURBANCE THEORY

Flow over a wedge and a cone- Blast wave analogy, -Newtonian impact theory- Busemann centrifugal correction -Shock expansion method- Tangent cone and tangent wedge methods Pressure distribution in separated regions and in reacting flows.

UNIT-III - BASIC ASPECTS OF HYPERSONIC VISCOUS FLOWS AND AERODYNAMIC HEATING

Introduction to viscous flow and pressure interactions over flat plate- Boundary layers Reference temperature method-Entropy layer effects on aerodynamic heating.

UNIT-IV - HYPERSONIC VEHICLE DESIGN

Supersonic Inlet design Strong and weak interactions-Shock wave/ boundary layer interactions Concept of SERN, Design aspects of various Hypersonic vehicles like X-43, HSTDV, Hyshot

UNIT-V - EXPERIMENTAL METHODS FOR HYPERSONIC FLOWS:

Arc Jet facilities, Impulse facilities, hypersonic wind tunnels, shock tunnels, gun tunnels, free piston shock tunnels, expansion tubes etc. Flow visualization techniques, model testing.

Text Books

1. "Hypersonic and High Temperature Gas Dynamics", Anderson, J.D, McGraw-Hill, 1989.
2. "Hypersonic Aerothermodynamics", Bertin, J.J., AIAA, 1994.

Reference Books:

1. "Introduction to Hypersonic flow", Cherni C G, Academic Press,1961
2. "Hypersonic Flow Theory", Hayes W D and Problein R F, Academic Press 1959
3. "Elements of Hypersonic Aerodynamics", Cox R N and Crabtree L P, London 1965

Outcomes:

The student should be able to

- Estimation of aerodynamic characteristics of different geometries in hypersonic conditions.
- Application aerodynamic theories in the design hypersonic vehicles.
- Validation of experimental results with analytical results.

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OPEN ELECTIVE

(R24DME51) NON-CONVENTIONAL ENERGY SOURCES

UNIT-I

Introduction: Energy Scenario, Survey of energy resources. Classification and need for conventional energy resources.

Solar Energy: The Sun-sun-Earth relationship, Basic matter to waste heat energy circuit, Solar Radiation, Attention, Radiation measuring instruments.

Solar Energy Applications: Solar water heating. Space heating, Active and passive heating, Energy storage, Selective surface, Solar stills and ponds, solar refrigeration, Photovoltaic generation.

UNIT -II

Geothermal Energy: Structure of earth, Geothermal Regions, Hot springs. Hot Rocks, Hot Aquifers. Analytical methods to estimate thermal potential. Harnessing techniques, Electricity generating systems.

UNIT-III

Direct Energy Conversion: Nuclear Fusion, Fusion reaction, P-P cycle, Carbon cycle, Deuterium cycle, Condition for controlled fusion, Fuel cells and photovoltaic, Thermionic and Thermoelectric generation and MHD generator.

Hydrogen Gas as Fuel: Production methods, Properties, I.C. Engines applications, Utilization strategy, Performances.

UNIT-IV

Bioenergy: Biomass energy sources. Plant productivity, Biomass wastes, aerobic and an aerobic bio-conversion processes, Raw material and properties of bio-gas, Bio-gas plant technology and status, the energetic and economics of biomass systems, Biomass gasification

UNIT-V

Wind Energy: Wind, Beaufort number, Characteristics, Wind energy conversion systems, Types, Betz model. Interference factor. Power coefficient, Torque coefficient and Thrust coefficient, lift machines and Drag machines. Matching Electricity generation.

Energy from Oceans: Tidal energy, Tides, Diurnal and semi-diurnal nature, Power from tides, Wave Energy, Waves, Theoretical energy available. Calculation of period and phase velocity of waves,Wave power systems, submerged devices. Ocean thermal Energy, Principles, Heat exchangers, Pumping requirements, Practical considerations.

TEXTBOOKS:

1. Non-conventional Energy Sources / GD Rai/Khanna publications.
2. Non-Conventional Energy Sources and Utilisation (Energy Engineering)/ R KRajput/ S.Chand.
3. Renewable Energy Sources /Twidell& Weir/Taylor and Francis/ 2nd special Indian edition.

REFERENCE BOOKS:

1. Renewable Energy Resources- Basic Principles and Applications/ G.N.Tiwari and M.K.Ghosal Narosa Publications.
2. Renewable Energy Resources/ John Twidell& Tony Weir/Taylor & Francis/2nd edition.
3. Non-Conventional Energy / K.Mittal/ Wheeler.

Course Outcomes:

- The concept of solar energy and their applications in different fields.
- The ways to harness energy from nonconventional energy sources like geothermal, wind and ocean.
- Understand Biogas generation and its impact on the Environment.
- Understand the different nonconventional sources and power generation techniques.
- Understand the role of Nonconventional Energy Sources when conventional sources are scarce in nature.

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OPEN ELECTIVE			
(R24DME52) INDUSTRIAL SAFETY	**3**	**-**	**3**

Objectives:

- To explain the concept of various industrial safety methods.
- To outline division aspects measurements of safety performance.

UNIT-I:

Importance of Safety, health and environment. Health safety and environmental policy, fundamentals of safety, classification of accidents, Managements responsibility, objectives of safety management, National safety council, Employees state insurance act 1948, approaches to prevent accidents, principles of safety management, safety organization, safety auditing, maintenance of safety, measurements of safety performance, industrial noise and noise control, Industrial Psychology, Industrial accidents and prevention. Introduction to OSHAS 18001 AND OSHA.

UNIT II:

Process safety management (P.S.M) as per OSHA, legal aspects of safety, safety with respect to plant and machinery, the explosive act 1884, Petroleum act 1934, personal protective equipment, classification of hazards, protection of respiratory system, work permit system, hazards in refineries and process plants, safety in process plants, pollution in some typical process industry.

UNIT III:

Safe working practices, housekeeping, safe working environment, safety device and tools, precaution in use of ladders, safety instruction during crane operation, safety instruction for welding, burning and cutting and gas welding equipment, electrical safety, case studies, safety in useof electricity, electric shock phenomena, Occurrence of electric shock, medical analysis of electric shock and its effect, safety procedures in electric plants, installation of Earthing system,

UNIT IV:

Safety in hazardous area, hazard in industrial zones, classification of industrial Enclosures for gases and vapors. Mechanical, Chemical, Environmental and Radiation hazards, Machine guards and safety devices, slings, load limits, lifting tackles and lifting equipment, hydrostatic test, Chemical hazards, industrial toxicology, toxic chemicals and its harmful effects on humans, factors influencing the effect of toxic materials, Units of concentration, control measure, environmental hazards, devices for measuring radiation, safety analysis and risk analysis, risk management, First aid, Safety measures to avoid occupational diseases.

UNIT V

Factories act – 1948 Stuatutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young persons – special provisions – penalties and procedures- Indian Boiler Act 1923, static and mobile pressure vessel rules (SMPV), motor vehicle rules, mines act 1952, workman compensation act, rules – electricity act and rules

Text books:

1. Industrial safety management by: L.M. Deshmukh Publishers: Tata Megraw Hill, New Delhi Year: 2006 Edition: First
2. The Factories Act 1948, Madras Book Agency, Chennai, 2000

References:

1. Industrial safety health and environment Management system By: R.K. Jain & Sunil S. Rao Publishers: Khanna Publishers Year: 2008 Edition: Second
2. The Indian boilers act 1923, Commercial Law Publishers (India) Pvt.Ltd., Allahabad.
3. "Accident prevention manual for industrial operations", N.S.C.,Chicago, 1982.
4. Industrial Safety and Environment by Amit Gupta
5. "Safety in Industry" N.V. Krishnan Jaico Publishery House, 1996.

Outcome of course:

- Educate students about how to reduce work place hazards and to encourage the standard of Safety, Health & Environment programme, so as to aim 0% accidents and 100% safety in different industries in which Industrial Safety plays an important role.
- This has the blending mixture of both Learning and Skills.

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OPEN ELECTIVE

(R24DME53) OPERATIONS RESEARCH

Objectives:

- To familiarize the students with the use of practice oriented mathematical applications for optimization functions in an organization.
- To familiarize the students with various tools of optimization, probability, statistics and simulation,
- To applicable in particular scenarios in industry for better management of various resources.

UNIT–I

Introduction: Development – Definition– Characteristics and Phases – Types of models – operation Research models– applications.

Allocation: Linear Programming Problem Formulation – Graphical solution – Simplex method – Artificial variables techniques -Two–phase method, Big-M method.

UNIT–II

Transportation Problem – Formulation – Optimal solution, unbalanced transportation problem – Degeneracy. Assignment problem – Formulation – Optimal solution - Variants of Assignment Problem-Travelling Salesman problem.

Sequencing – Introduction – Flow –Shop sequencing – n jobs through two machines – n jobs through three machines – Job shop sequencing – two jobs through 'm' machines.

UNIT–III

Replacement: Introduction – Replacement of items that deteriorate with time – when money value is not counted and counted – Replacement of items that fail completely, group replacement.

Theory of Games: Introduction – Minimax (maximin) – Criterion and optimal strategy – Solution of games with saddle points – Rectangular games without saddle points – 2 X 2 games – dominance principle – m X 2 & 2 X n games -graphical method.

UNIT–IV

Waiting Lines: Introduction – Single Channel – Poisson arrivals – exponential service times – with infinite population and finite population models– Multichannel – Poisson arrivals – exponential service times with infinite population single channel Poisson arrivals.

Inventory: Introduction – Single item – Deterministic models – Purchase inventory models with one price break and multiple price breaks – shortages are not allowed – Stochastic models – demand may be discrete variable or continuous variable – Instantaneous production. Instantaneous demand and continuous demand and no set up cost.

UNIT–V

Dynamic Programming: Introduction – Bellman's Principle of optimality – Applications of dynamic programming- capital budgeting problem – shortest path problem – linear programming problem.

Simulation: Definition – Types of simulation models – phases of simulation– applications of simulation – Inventory and Queuing problems – Advantages and Disadvantages – Simulation Languages.

TEXT BOOKS:

1. Operations Research / S.D.Sharma -Kedarnath
2. Introduction to O.R/Hiller & Libermann (TMH).
3. Introduction to O.R /Taha/PHI

REFERENCE BOOKS:

1. Operations Research /A.M.Natarajan,P.Balasubramani,A. Tamilarasi/Pearson . Education.
2. Operations Research / R.Pannerselvam,PHI Publications.
3. Operation Research /J.K.Sharma/MacMilan.

OUTCOMES:

- Student will be able to illustrate the need to optimally utilize the resources in various types of industries.
- Apply and analyze mathematical optimization functions to various applications.
- Demonstrate cost effective strategies in various applications in industry.

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OPEN ELECTIVE

(R24DHS51) BUSINESS ANALYTICS

Learning Objective: To understand the importance of ever-increasing volume, variety and velocity of data in organization and application of data analytical tools for decision making.

Learning Outcome: Students will be able to understand a) Importance of Analytics b) Understanding the analytical tools c) Application of Analytical tools to solve business problems.

Unit-I: Introduction to Business Analytics: Importance, Scope, Evolution, Classification, and Application; Data Structure-Visualization of Data, Data Architecture, Measurement Scale; Decision Models-Classification, Structure of Decision Models; Data Structure and Data View-Understanding of data, exploring data using pivot tables.

Unit-II: Descriptive Analytics: Descriptive Statistical Measures–Population and samples, Measures of location, Measures of Dispersion, Measures of variability, measures of Association. Probability distribution and Data Modeling – Discrete Probability distribution, Continuous Probability distribution, Random sampling from Probability Distribution, Data Modeling and Distribution fitting.

Unit-III: Predictive Analytics: Karl Pearson Correlation Techniques -Multiple Correlation-Spearman's Rank Correlation-Simple and Multiple Regression-Regression by the method of least squares – Building good regression models –Regression with categorical independent variables --Linear Discriminant Analysis-One way and Two Way ANOVA

Unit-IV: Data Mining: Scope of Data Mining, Data Exploration and Reduction, Unsupervised learning –cluster analysis, Association rules, Supervised Learning-Partition Data, Classification Accuracy, prediction Accuracy, k-nearest neighbours, Classification and regression trees, Logistics Regression.

Unit-V: Simulation: Random Number Generation, Monte Carlo Simulation, What if Analysis, Verification and Validation, Advantages and Disadvantages of Simulation, Risk Analysis, Decision Tree Analysis.

References:

- James Evans, Business Analytics, 2e, Pearson.
- Camm, Cochran, Fry, Ohlmann, Anderson, Sweeney, Williams Essential of Business Analytics, Cengage Learning.
- Thomas Eri, Wajid Khattack & Paul Buhler: Big Data Fundamentals, Concepts, drivers and Techniques by Prentice Hall of India, New Delhi.
- Akil Maheswari: Big Data, Upskill ahead by Tata McGraw Hill, New Delhi.
- Seema Acharya & Subhashini Chellappan: Big Data and Analytics, Wiley Publications, New Delhi.
- Christian Albright, Wayne L. Winston: Business Analytics: Data Analysis & Decision Making, Cengage Learning

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OPEN ELECTIVE
(R24DCS51) SCRIPTING LANGUAGES

Objectives: The course demonstrates an in depth understanding of the tools and the scripting languages necessary for design and development of applications dealing with Bio-information/ Bio-data. The instructor is advised to discuss examples in the context of Bio-data/ Bio-information application development.

UNIT I

Introduction to PERL and Scripting Scripts and Programs, Origin of Scripting, Scripting Today, Characteristics of Scripting Languages, Web Scripting, and the universe of Scripting Languages. PERL-Names and Values, Variables, Scalar Expressions, Control Structures, arrays, list, hashes, strings, pattern and regular expressions, subroutines, advance perl - finer points of looping, pack and unpack, filesystem, eval, data structures, packages, modules, objects, interfacing to the operating system, Creating Internet ware applications, Dirty Hands Internet Programming, security Issues.

UNIT II

PHP Basics- Features, Embedding PHP Code in your Web pages, Outputting the data to the browser, Datatypes, Variables, Constants, expressions, string interpolation, control structures, Function, Creating a Function, Function Libraries, Arrays, strings and Regular Expressions.

UNIT III

Advanced PHP Programming Php and Web Forms, Files, PHP Authentication and Methodologies - Hard Coded, File Based, Database Based, IP Based, Login Administration, Uploading Files with PHP, Sending Email using PHP, PHP Encryption Functions, the Mcrypt package, Building Web sites for the World – Translating Websites- Updating Web sites Scripts, Creating the Localization Repository, Translating Files, text, Generate Binary Files, Set the desired language within your scripts, Localizing Dates, Numbers and Times.

UNIT IV

TCL Structure, syntax, Variables and Data in TCL, Control Flow, Data Structures, input/output, procedures, strings, patterns, files, Advance TCL- eval, source, exec and up level commands, Name spaces, trapping errors, event driven programs, making applications internet aware, Nuts and Bolts Internet Programming, Security Issues, C Interface. Tk- Visual Tool Kits, Fundamental Concepts of Tk, Tk by example, Events and Binding, Perl-Tk.

UNIT V

Python Introduction to Python language, python-syntax, statements, functions, Built-in-functions and Methods, Modules in python, Exception Handling, Integrated Web Applications in Python – Building Small, Efficient Python Web Systems, Web Application Framework.

TEXT BOOKS:

1. The World of Scripting Languages, David Barron, Wiley Publications.
2. Python Web Programming, Steve Holden and David Beazley, New Riders Publications.
3. Beginning PHP and MySQL, 3rd Edition, Jason Gilmore, Apress Publications (Dreamtech)

REFERENCE BOOKS:

1. Open Source Web Development with LAMP using Linux, Apache, MySQL, Perl and PHP, J.Lee and B.Ware (Addison Wesley) Pearson Education.
2. Programming Python, M.Lutz, SPD.
4. PHP 6 Fast and Easy Web Development, Julie Meloni and Matt Telles, Cengage Learning Publications.
5. PHP 5.1, I.Bayross and S.Shah, The X Team, SPD.
6. Core Python Programming, Chun, Pearson Education.
7. Guide to Programming with Python, M.Dawson, Cengage Learning.
8. Perl by Example, E.Quigley, Pearson Education.
9. Programming Perl, Larry Wall, T.Christiansen and J.Orwant, O'Reilly, SPD.
10. Tcl and the Tk Tool kit, Ousterhout, Pearson Education.
11. PHP and MySQL by Example, E.Quigley, Prentice Hall(Pearson).
12. Perl Power, J.P.Flynt, Cengage Learning.
13. PHP Programming solutions, V.Vaswani, TMH.

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OPEN ELECTIVE

(R24DAE51) MATHEMATICAL MODELING TECHNIQUES

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 Gershen feld, 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

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OPEN ELECTIVE

(R24DEC51) EMBEDDED SYSTEMS PROGRAMMING

Unit 1 - Embedded OS (Linux) Internals

Linux internals: Process Management, File Management, Memory Management, I/O Management. Overview of POSIX APIs, Threads – Creation, Cancellation, POSIX Threads Inter Process Communication - Semaphore, Pipes, FIFO, Shared Memory

Kernel: Structure, Kernel Module Programming Schedulers and types of scheduling.

Interfacing: Serial, Parallel Interrupt Handling Linux Device Drivers: Character, USB, Block & Network

Unit 2 – Open source RTOS

Basics of RTOS: Real-time concepts, Hard Real time and Soft Real-time, Differences between General Purpose OS & RTOS, Basic architecture of an RTOS, Scheduling Systems, Inter-process communication, Performance Matric in scheduling models, Interrupt management in RTOS environment, Memory management, File systems, I/O Systems, Advantage and disadvantage of RTOS.

Unit 3 – Open Source RTOS Issues

POSIX standards, RTOS Issues - Selecting a Real Time Operating System, RTOS comparative study. Converting a normal Linux kernel to real time kernel, Xenomai basics.

Overview of Open source RTOS for Embedded systems (Free RTOS/ Chibios -RT) and application development.

Unit 4 – VxWorks / Free RTOS

VxWorks/ Free RTOS Scheduling and Task Management - Realtime scheduling, Task Creation, Intertask Communication, Pipes, Semaphore, Message Queue, Signals, Sockets, Interrupts I/O Systems - General Architecture, Device Driver Studies, Driver Module explanation, Implementation of Device Driver for a peripheral

Unit 5 – Case study

Cross compilers, debugging Techniques, Creation of binaries & porting stages for Embedded Development board (Beagle Bone Black, Rpi or similar), Porting an Embedded OS/ RTOS to a target board (). Testing a real time application on the board

TEXT BOOKS:

1. Essential Linux Device Drivers, Venkateswaran Sreekrishnan
2. Writing Linux Device Drivers: A Guide with Exercises, J. Cooperstein
3. Real Time Concepts for Embedded Systems – Qing Li, Elsevier

REFERENCES:

1. Embedded Systems Architecture Programming and Design: Raj Kamal, Tata McGraw Hill
2. Embedded/Real Time Systems Concepts, Design and Programming Black Book, Prasad, KVK
3. Software Design for Real-Time Systems: Cooling, J E Proceedings of 17the IEEE Real-Time Systems Symposium December 4-6, 1996 Washington, DC: IEEE Computer Society
4. Real-time Systems – Jane Liu, PH 2000
5. Real-Time Systems Design and Analysis: An Engineer's Handbook: Laplante, Phillip A
6. Structured Development for Real - Time Systems V1: Introduction and Tools: Ward, Paul T & Mellor, Stephen J
7. Structured Development for Real - Time Systems V2: Essential Modeling Techniques: Ward, Paul T & Mellor, Stephen J
8. Structured Development for Real - Time Systems V3: Implementation Modeling Techniques: Ward, Paul T & Mellor, Stephen J
9. Monitoring and Debugging of Distributed Real-Time Systems: TSAI, Jeffrey J P & Yang, J H
10. Embedded Software Primer: Simon, David E.
11. Embedded Systems Architecture Programming and Design: Raj Kamal, Tata McGraw Hill

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(R24D7692) DISSERTATION PHASE – I/INDUSTRIAL PROJECT

The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following

- Relevance to social needs of society
- Relevance to value addition to existing facilities in the institute
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

the student should complete the following:

- Literature survey Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility / modular approaches
- Implementation and Verification
- Report and presentation

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(R24D7693) DISSERATATION PAHSE-II

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them. It may be based on:

- Experimental verification / Proof of concept.
- Design, fabrication, testing of Communication System.

The viva-voce examination will be based on the above report and work.

Guidelines for Dissertation Phase – I and II

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e., Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e., department s laboratories and centers OR in industry allotted through department s T & P coordinator.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include IEEE/IET/IETE/Springer/Science Direct/ACM journals in the areas of Computing and Processing (Hardware and Software), Circuits - Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work

Course Outcomes:

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

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.