# NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

**(Deemed to be University Under Section 3 of the UGC Act, 1956)**
**Kumaracoil, Thuckalay**

## DEPARTMENT OF AERONAUTICAL ENGINEERING

## M.E. AERONAUTICAL ENGINEERING

## CURRICULUM AND SYLLABI

## REGULATION 2023

# NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, Kumaracoil
## Regulation: 2023
### Curriculum and Syllabi

### M.E Programme
### DEPARTMENT OF AERONAUTICAL ENGINEERING

### M.E. AERONAUTICAL ENGINEERING

**Vision of the University**

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

**Mission of the University**

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

**Faculty of Aeronautical and Space Technology**

**Department of Aeronautical Engineering**

**Vision Statement of the Department:** To train discerning graduates to become well educated in Aeronautical Engineering Masters with required knowledge with effective teaching, learning, analytical thinking, written and oral communication skills, creativity, vision, enthusiasm and above all professional ethics to become leaders in industry, research & society etc.

**Mission Statement of the Department:** To offer a world-class, affordable education, in Aeronautical Engineering, backed by the services of engineering fundamentals augmented by the development of interpersonal skills, social values, experiential learning, and flair for life-long learning with highly qualified faculty and extensive experience in basic and applied research, covering different areas of Aeronautical Engineering.

**Description of the programme**

| Programme Educational Objectives - PEO | |
|---|---|
| PEO-01 | To strengthen the fundamental subject knowledge and practical skills of the aeronautical Students for meeting the requirements of Aeronautical industries and educational institutions including research centre. |
| PEO-02 | To give quality technical education to the students covering latest technological concepts for facilitating them to diagnose and solve industrial problems. |
| PEO-03 | To provide necessary technical, managerial and soft skills to the students for making them industry ready. |
| PEO-04 | To shape the students for becoming socially, intellectually and ethically responsible Aeronautical Engineers. |
| PEO-05 | To mould graduates to acquire and exercise efficient communication skills, eminent leadership qualities and team work to challenge the contemporary issues to broader social context. |

| | Graduate Attributes |
|---|---|
| GA -1 | **Innovative Engineering Solutions:** Develop creative and innovative solutions to complex engineering problems, incorporating the latest technologies and approaches to address current and future challenges. |
| GA-2 | **Global Perspective in Engineering:** Understand and apply engineering solutions in a global context, recognizing the diversity of global issues, standards, and the impact of engineering decisions on different cultures and communities |
| GA-3 | **Sustainable Development and Green Engineering:** Design and implement engineering solutions that prioritize sustainability, resource efficiency, and environmental protection, contributing to a sustainable future. |
| GA-4 | **Social Responsibility and Community Engagement:** Demonstrate a commitment to social responsibility by engaging with and contributing to local communities, understanding societal needs, and addressing social challenges through engineering practices |
| GA-5 | **Adaptability and Lifelong Learning:** Exhibit a proactive approach to continuous learning and adaptability, keeping pace with technological advancements and industry changes, and engaging in professional development activities. |

| | |
|---|---|
| GA-6 | **Entrepreneurship and Innovation:** Foster an entrepreneurial mindset, identifying opportunities for innovation and creating value through new technologies, products, and processes that meet market needs. |
| GA-7 | **Interdisciplinary Collaboration:** Work effectively in interdisciplinary teams, integrating knowledge from various fields to develop comprehensive solutions to complex engineering problems. |
| GA-8 | **Ethical Leadership and Integrity:** Lead with integrity and ethical principles, ensuring transparency, fairness, and respect in all professional and personal interactions |
| GA-9 | **Digital and Data Literacy:** Utilize advanced digital tools and data analytics techniques to solve engineering problems, optimize processes, and make informed decisions based on data-driven insights. |
| GA-10 | **Safety, Health, and Risk Management:** Prioritize safety, health, and risk management in engineering practices, ensuring the well-being of individuals and communities while minimizing potential risks and hazards. |
| GA-11 | **Effective Communication and Negotiation Skills:** Communicate ideas, solutions, and technical information effectively to a variety of audiences, and engage in negotiation to resolve conflicts and reach consensus. |
| GA-12 | **Impact Assessment and Policy Making:** Assess the impact of engineering projects on society and the environment, and contribute to policy-making processes that promote sustainable and responsible engineering practices. |

| **Programme Outcome - PO** | |
|---|---|
| PO-A | To apply the knowledge of mathematics, science and engineering. |
| PO-B | Ability to analyze, interpret and solve complex engineering problems. |
| PO-C | Ability to visualize and work on laboratory for multidisciplinary needs. |
| P0-D | Ability to integrate all the modes of analysis for accuracy solutions during arbitrary problems. |
| PO-E | Ability to demonstrate the skills using modern engineering tools and equipment. |
| PO-F | Ability to function on multidisciplinary teams. |

| | |
|---|---|
| PO-G | Graduates will be able to communicate effectively in both verbal and written form. |
| PO-H | Graduates will contribute to the needs of the society. |
| PO-I | Able to get broad education necessary to understand the impact of engineering solutions in Global economic and social content. |
| PO-J | Ability to demonstrate the knowledge of professional and ethical responsibilities. |
| PO-K | Graduates will achieve successful career in Global industry. |
| PO-L | Graduates will develop confidence for self-esteem and ability for lifelong learning. |
| PO-M | Ability to lead the future of Aeronautics. |

**Mapping of Graduate Attributes and Programme Educational Objectives (PEO)**

| GAs / PEOs | G A-01 | GA-02 | GA-03 | GA-04 | GA-05 | GA-06 | GA 07 | GA-08 | GA-09 | GA-10 | GA-11 | GA-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PEO-01 | H | A | A | N | A | N | A | N | A | N | A | A |
| PEO-02 | A | A | N | H | A | A | N | N | N | N | A | A |
| PEO-03 | N | N | N | N | N | H | A | A | N | N | H | A |
| PE0-04 | N | N | A | H | N | A | N | N | N | H | N | A |
| PEO-05 | N | A | N | A | N | A | N | H | N | N | N | N |

H-Highly Associated A-Associated N – Not Associated

**Mapping of Graduate Attributes and Programme Outcomes (PO)**

| GAs / PEOs | GA-01 | GA-02 | GA-03 | GA-04 | GA-05 | GA-06 | GA-07 | GA-08 | GA-09 | GA-10 | GA-11 | GA-12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PO-A | N | A | N | A | N | N | N | N | N | N | N | N |
| PO-B | H | A | N | N | A | N | H | N | H | N | N | N |
| PO-C | A | H | A | N | N | N | N | N | A | N | N | N |
| PO-D | H | A | A | N | N | N | A | N | H | N | N | A |
| PO-E | H | A | A | N | N | N | A | N | A | N | N | N |
| PO-F | A | A | A | N | N | N | A | N | H | A | A | A |
| PO-G | N | N | N | H | N | A | N | A | N | N | H | N |
| PO-H | N | A | A | H | N | A | N | A | N | A | A | A |
| PO-I | N | A | A | H | N | A | N | A | N | A | A | A |
| PO-J | N | A | A | H | N | A | N | H | N | H | A | A |

H-Highly Associated A-Associated N – Not Associated

**Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)**

| PEO / PO | PEO-01 | PEO-02 | PEO-03 | PEO-04 | PEO-05 |
|---|---|---|---|---|---|
| PO-A | A | A | N | N | N |
| PO-B | A | A | N | N | N |
| PO-C | H | A | N | N | N |
| PO-D | A | A | N | N | N |
| PO-E | A | A | N | A | N |
| PO-F | A | A | N | N | N |
| PO-G | A | N | H | A | H |
| PO-H | N | N | A | A | A |
| PO-I | N | N | N | A | N |
| PO-J | N | N | N | H | N |

H-Highly Associated A-Associated N – Not Associated

Duration of the ME Programme: 2 Years
Total Credit: 70

## Curriculum

### SEMESTER I

| SL. NO. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | MA4502 | Advanced Numerical Methods | 3 | 1 | 0 | 4 |
| 2. | OE45D1 | Research Methodology &IPR | 2 | 0 | 0 | 2 |
| 3. | AE4501 | Aircraft and Rocket Propulsion | 3 | 0 | 0 | 3 |
| 4. | AE4502 | Aircraft Structural Mechanics | 3 | 0 | 0 | 3 |
| 5. | AE4503 | Aircraft Aerodynamics | 3 | 0 | 0 | 3 |
| 6. | AE**** | Department Elective-I | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7. | AE4571 | Aircraft Structures and Aero Engines Lab | 0 | 0 | 3 | 2 |
| **TOTAL** | | | **17** | **1** | **3** | **20** |

### SEMESTER II

| SL. NO. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | AE4504 | Advanced Flight Dynamics | 3 | 0 | 0 | 3 |
| 2. | AE4505 | Advanced Computational Fluid Dynamics | 3 | 0 | 0 | 3 |
| 3. | AE4506 | Analysis of Composite Structures | 3 | 0 | 0 | 3 |
| 4. | AE4507 | Advanced Finite Element Methods | 3 | 0 | 0 | 3 |
| 5. | AE**** | Department Elective-II | 3 | 0 | 0 | 3 |
| 6. | AE**** | Department Elective-III | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7. | AE4572 | Airframe & Composite Materials Lab | 0 | 0 | 3 | 1 |
| **TOTAL** | | | **18** | **0** | **3** | **19** |

## SEMESTER III

| SL. NO. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | AE**** | Department Elective – IV | 3 | 0 | 0 | 3 |
| 2. | AE**** | Department Elective – V | 3 | 0 | 0 | 3 |
| 3. | XXXX | Open Elective – I | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 4. | AE45P1 | Project Work Phase – I | 0 | 0 | 18 | 6 |
| **TOTAL** | | | **9** | **0** | **18** | **15** |

## SEMESTER IV

| SL. NO. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **PRACTICAL** | | | | | | |
| 1. | AE45P5 | Project Work Phase – II | 0 | 0 | 32 | 16 |
| **TOTAL** | | | **0** | **0** | **32** | **16** |

## LIST OF DEPARTMENT ELECTIVES
## SEMESTER I

| SL. NO | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45A1 | Theory of Vibrations | 3 | 0 | 0 | 3 |
| 2. | AE45A2 | Rocketry and Space Mechanics | 3 | 0 | 0 | 3 |
| 3. | AE45A3 | Wind tunnel Techniques | 3 | 0 | 0 | 3 |
| 4. | AE45A4 | Experimental Stress Analysis | 3 | 0 | 0 | 3 |
| 5. | AE45A5 | Aircraft Design | 3 | 0 | 0 | 3 |

## SEMESTER II

| Sl. NO | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45A6 | High Speed Jet Flows | 3 | 0 | 0 | 3 |
| 2. | AE45A7 | Hypersonic Aerodynamics | 3 | 0 | 0 | 3 |
| 3. | AE45A8 | Advanced Propulsion Systems | 3 | 0 | 0 | 3 |
| 4. | AE45A9 | Advanced Heat Transfer | 3 | 0 | 0 | 3 |
| 5. | AE45B1 | Experiments Methods in Fluid Mechanics | 3 | 0 | 0 | 3 |
| 6. | AE45B2 | Airworthiness and Air Regulations | 3 | 0 | 0 | 3 |
| 7. | AE45B3 | Aircraft Systems Engineering | 3 | 0 | 0 | 3 |

## SEMESTER III

| SI. NO | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45B4 | Aero Elasticity | 3 | 0 | 0 | 3 |
| 2. | AE45B5 | Theory of boundary layers | 3 | 0 | 0 | 3 |
| 3. | AE45B6 | Smart Materials and Structural Health Monitoring | 3 | 0 | 0 | 3 |
| 4. | AE45B7 | Gas Dynamics | 3 | 0 | 0 | 3 |
| 5. | AE45B8 | Fatigue and Fracture Mechanics | 3 | 0 | 0 | 3 |
| 6. | AE45B9 | Avionics | 3 | 0 | 0 | 3 |

## LIST OF OPEN ELECTIVES

| SL. No. | SUBJECT CODE | SUBJECT NAME | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | OE45D1 | Research Methodology and IPR | 2 | 0 | 0 | 2 |
| 2. | OE45D2 | Business Analytics | 3 | 0 | 0 | 3 |
| 3. | OE45D3 | Industrial Safety | 3 | 0 | 0 | 3 |
| 4. | OE45D4 | Operations Research | 3 | 0 | 0 | 3 |
| 5. | OE45D5 | Composite Materials | 3 | 0 | 0 | 3 |
| 6. | OE45D6 | Waste to Energy | 3 | 0 | 0 | 3 |

**Syllabus**

**SEMESTER I**

| SL. NO. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | MA4502 | Advanced Numerical Methods | 3 | 1 | 0 | 4 |
| 2. | OE45D1 | Research Methodology & IPR | 2 | 0 | 0 | 2 |
| 3. | AE4501 | Aircraft and Rocket Propulsion | 3 | 0 | 0 | 3 |
| 4. | AE4502 | Aircraft Structural Mechanics | 3 | 0 | 0 | 3 |
| 5. | AE4503 | Aircraft Aerodynamics | 3 | 0 | 0 | 3 |
| 6. | AE**** | Department Elective-I | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7. | AE4571 | Aircraft Structures and Aero Engines Lab | 0 | 0 | 3 | 2 |
| **TOTAL** | | | **17** | **1** | **3** | **20** |

| MA4502 | ADVANCED NUMERICAL METHODS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**(Common to Thermal, Aero and AM)**

**OBJECTIVE**

To derive numerical methods for various mathematical operations and tasks, such as the solution of linear and nonlinear equations, interpolation, differentiation, integration and the solution of differential equations and finite element method in solving partial differential equations and simulation.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the algebraic or transcendental equation, linear and nonlinear system of equations and differential equations using an appropriate numerical method. | U, A, An, E |
| CO-02 | To establish the initial boundary value problems and boundary value problems using single step methods and finite difference method. | U, A, An, E |
| CO-03 | Solving elliptic, parabolic and hyperbolic partial differential equations by finite difference methods. | U, A, An, E |
| CO-04 | To provide basic knowledge in finite elements method in solving partial differential equations. | U, A, An, E |
| CO-05 | To study the application of simulation to solve queuing problems for real world applications. | U, A, An, E |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO - I | PO-J | PO-K | PO -L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | M | M | M | N | M | N | L | M | N | M | L | L |
| **CO-02** | S | S | M | L | S | M | N | S | L | N | M | N | M |
| **CO-03** | M | L | M | N | N | M | N | M | N | N | M | S | L |
| **CO-04** | S | M | L | S | L | S | N | L | S | N | S | N | L |
| **CO-05** | M | S | S | L | N | M | N | L | L | N | M | S | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: ALGEBRAIC EQUATIONS 9**

Systems of linear equations: Gauss elimination method – Pivoting techniques– Jacobi, Gauss Seidel, SOR iteration methods – Conditions for convergence – Systems of nonlinear equations: Fixed point iterations and Newton's method.

**UNIT II:FIRST AND SECOND ORDER ORDINARY DIFFERENTIALEQUATIONS9**

Solution of first order differential equations -Single step Methods: Taylor's Series, Euler's method Runge–Kutta method for system of IVPs – Numerical stability of Runge–Kutta method – Adams – Bash forth multistep method, Shooting method, BVP : Finite difference method.

**UNIT III: FIRST AND SECOND ORDER PARTIAL DIFFERENTIAL EQUATIONS9**

Finite difference solution of one dimensional heat equation: Bender Schmidt Method and Crank- Nicolson Method–One dimensional wave equation and two dimensional Laplace and Poisson equations.

**UNIT IV: FINITE ELEMENT ANALYSIS 9**

Basics of finite element method: Weak formulation, Weighted residual method – Shape functions for linear and triangular element – Finite element method for two point boundary value problems, Laplace and Poisson equations.

**UNIT V: SIMULATION 9**

Discrete Event Simulation – Stochastic Simulation – Monte Carlo Simulation – Generation of Random Numbers using Congruent method – Applications in inventory and Queuing models.

**L: 45 + T: 15, TOTAL: 60 HOURS**

**REFERENCES**


1. Grewal B. S. and Grewal J.S., "Numerical Methods in Engineering and Science", Seventh Edition, Khanna Publishers, New Delhi, 2007.
2. Gupta S.K., "Numerical Methods for Engineers",4th Edition, New Age Publishers, 2019.
3. Jain M.K., Iyengar S.R.K and Jain R.K, "Numerical method for scientific and Engineering Computations", New Age International (P) Ltd., Publishers, 2003.
4. Kandasamy P., Thilagavathy K. and Gunavathy K., "Numerical Methods", S.Chand and Company Ltd.,Ramnagar, New Delhi, 2010.
5. SastryS.S., "Introductory Methods of Numerical Analysis", 5th Edition, PHI Learning, 2015.

6. Smith G. D., "Numerical Solutions of Partial Differential Equations: Finite Difference Methods", Clarendon Press, 1985.
7. Taha H.A., “Operations Research: An Introduction”, Ninth Edition, Pearson Education Edition, Asia, New Delhi, 2002.

| AE4501 | AIRCRAFT AND ROCKET PROPULSION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To understand the principles of operation and design of aircraft and spacecraft power plants.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To make the students to understand the elements of aircraft propulsion | U |
| CO-02 | To demonstrate the various types of propellers | A |
| CO-03 | To understand concept of inlets, combustion chamber and nozzles. | E |
| CO-04 | To make the students to understand the basic principles of compressor, turbine and fans. | A |
| CO-05 | To evaluate the performance of types of rocket engines. | E |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO - I | PO-J | PO-K | PO -L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | M | N | M | L | S | M | N | M | L | M |
| **CO-02** | M | N | S | L | S | M | N | S | L | N | M | N | M |
| **CO-03** | S | L | M | N | N | M | L | M | N | N | M | S | M |
| **CO-04** | S | M | L | S | L | S | N | L | S | L | S | N | M |
| **CO-05** | M | S | L | L | N | M | L | L | L | N | M | S | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: ELEMENTS OF AIRCRAFT PROPULSION 9**

Review of Thermodynamic cycles - Classification of power plants – Methods of aircraft propulsion – Propulsive efficiency – Specific fuel consumption – Thrust and power- Factors affecting thrust and power- Illustration of working of piston engines and Gas turbine engines – Characteristics of piston engine, turboprop, turbofan and turbojet engines, Ram jet, Scram jet – Methods of Thrust augmentation.

**UNIT II: PROPELLER THEORY 9**

Momentum theory, Blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters, prediction of static thrust- and in flight, pitch reversal, prop fans, ducted propellers, propeller noise, propeller selection,

propeller charts.

**UNIT III: INLETS, NOZZLES AND COMBUSTION CHAMBERS 9**

Subsonic and supersonic inlets – Relation between minimum area ratio and external deceleration ratio – Starting problem in supersonic inlets –Modes of inlet operation, jet nozzle – Efficiencies –Over expanded, under and optimum expansion in nozzles – Thrust reversal. Classification of Combustion chambers – Combustion chamber performance – Flame tube cooling – Flame stabilization.

**UNIT IV: AXIAL FLOW COMPRESSORS, FANS AND TURBINES 9**

Introduction to centrifugal compressors- Axial flow compressor- geometry- twin spools- three spools- stage analysis- velocity polygons- degree of reaction ― radial equilibrium theory- performance maps- axial flow turbines- geometry- velocity polygons- stage analysis- performance maps- thermal limit of blades and vanes.

**UNIT V: ROCKET AND ELECTRIC PROPULSION 9**

Introduction to rocket propulsion – Chemical equilibrium analysis - Classification of rockets based on propellants used – solid, liquid and hybrid – electric propulsion – classification- electro thermal – electro static – electromagnetic thrusters- geometries of Ion thrusters- beam/plume characteristics – hallthrusters.

**TOTAL: 45 HOURS**

**TEXT BOOKS:**


1. Hill,P.G. and Peterson, C.R. Mechanics and Thermodynamics of Propulsion, Addison – Wesley Longman Inc., 2nd edition 2009.
2. Cohen, H. Rogers, G.F.C. and Saravanamuttoo,H.I.H, Gas Turbine Theory, Longman, 7th edition, 2017.
3. H.S.Muhunda, "Fundamentals of Rocket Propulsion".


**REFERENCES:**


1. G.C. Oates, "Aerothermodynamics of Aircraft Engine Components", AIAA Education Series, 2003.
2. G.P.Sutton, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2017.
3. J Seddon & E L Goldsmith. " Intake Aerodynamics", AIAA education series. 1999.
4. W.P.Gill, H.J.Smith & J.E. Ziurys, "Fundamentals of Internal Combustion Engines as applied to Reciprocating, Gas turbine & Jet Propulsion Power Plants", Oxford & IBH Publishing Co., 1980.


| AE4502 | AIRCRAFT STRUCTURAL MECHANICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study different types of beams and columns subjected to various types of loading and support conditions with particular emphasis on aircraft structural components.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To apply the bending of beams in structural analysis. | A |

| | | |
|---|---|---|
| CO-02 | To understand the shear flow in thin-walled sections | U |
| CO-03 | Apply shear flow in closed sections | A |
| CO-04 | Evaluate the stability problems in structural analysis. | E |
| CO-05 | To analyze of aircraft structural components | An |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| **PO/CO** | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO - I | PO-J | PO-K | PO - L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | S | S | N | N | S | S | S | S | S | M |
| **CO-02** | S | S | S | M | S | N | N | M | S | S | S | M | M |
| **CO-03** | S | S | S | S | S | L | N | S | S | S | S | S | S |
| **CO-04** | S | M | S | S | N | M | L | S | S | M | S | S | S |
| **CO-05** | S | S | M | M | S | S | N | M | S | S | M | M | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: BENDING OF BEAMS** **9**

Elementary theory of pure bending – Stresses in beams of symmetrical and unsymmetrical sections — Box beams — Generalized theory of bending — Methods of bending stress determination — Principal axes method — Neutral axis method — 'k' method — Deflection of unsymmetrical beams – Stresses in Composite Beams – Idealization of cross-section – Wing spar sizing

**UNIT II: SHEAR FLOW IN THIN-WALLED SECTION** **9**

General stress, strain and displacement relationships for open section thin-walled beams – Concept of shear flow – Shear flow in thin walled open sections – Determinations of the shear centre – Symmetrical and unsymmetrical cross-sections – Shear flow due to bending in open sections – Torsion of thin-walled open section members & determination of stresses – Design ofthin-walled members

**UNIT III: SHEAR FLOW IN CLOSED SECTIONS** **9**

Shear flow in thin-walled closed sections – Symmetrical and unsymmetrical sections – Flexural shear flow in two flange, three flange and multi-flange box beams – Determinations of the shear centre — Bredt-Batho theory — Torsional shear flow in multi-cell tubes — Shear flow due to combined bending and torsion – Stress analysis of aircraft components – Tapered wing spar – Introduction to shear lag

**UNIT IV: STABILITY PROBLEMS** **9**

Stability problems of thin walled structures – Buckling of sheets under compression, shear, and combined loads – Plate buckling coefficient – Inelastic buckling of plates – Sheet-stiffener panels - Effective width – Failure stress in plates and stiffened panels – Crippling stress estimation – Local Buckling – Wagner beam theory – Experimental determination of critical load for a flat plate - Principles of stiffener/web construction

**UNIT V: ANALYSIS OF AIRCRAFT STRUCTURAL COMPONENTS 9**

Aircraft structural Loads – Symmetric maneuver loads – Load factor determination – Inertia loads – Aerodynamic loads & Schrenk's curve – V-N diagram – Shear force, bending moment andtorque distribution along the span of the wing and fuselage – Structural parts of wing and fuselage and their functions – Analysis of rings and frames

**TOTAL: 45 HOURS**

**TEXT BOOKS:**

1. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., 1980.
2. Megson, T.M.G; Aircraft Structures for Engineering Students, Edward Arnold, 2007.

**REFERENCES:**

1. Peery, D.J. and Azar, J.J., Aircraft Structures, 2nd Edition, McGraw-Hill, New York, 1993.
2. Stephen P. Tinnoshenko & S.woinowsky Krieger, Theory of Plates and Shells, 2nd Edition, McGraw-Hill, Singapore, 1990.
3. Rivello, R.M., Theory and Analysis of Flight structures, McGraw-Hill, N.Y., 1993
4. Bruce. K. Donaldson, "Analysis of Aircraft Structures: An Introduction", Cambridge UniversityPress, 2nd edition, 2012.
5. Sun. CT, "Mechanics of Aircraft Structures", Wiley publishers, 2nd edition, 2006.

| AE4503 | AIRCRAFT AERODYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To understand the principles of air foils, wings and airplane configuration in high speed flows.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To make the students to understand aerodynamic forces and moments | An |
| CO-02 | To understand concept of incompressible flow theory | U |
| CO-03 | To understand concept of compressible flow theory | R |
| CO-04 | To evaluate aerodynamic characteristics of airfoils, wings and aircraft configuration in high speed flows | E |
| CO-05 | To understand concept of viscous flow theory | U |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | S | L | L | N | M | L | S | M | N | M | L | L |
| **CO-02** | M | N | S | L | M | L | N | S | L | N | M | N | M |
| **CO-03** | S | L | M | N | N | M | L | M | N | N | M | S | L |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-04** | M | M | L | S | L | S | N | L | S | N | S | N | M |
| **CO-05** | S | S | L | L | N | M | N | L | L | N | M | S | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION TO AERODYNAMICS 10**

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

**UNIT II: INCOMPRESSIBLE FLOW THEORY 10**

Conformal Transformation, Karman ,Trefftz profiles, Kutta condition, Kelvin's Circulation Theorem and the Starting Vortex, Thin aerofoil Theory and its applications. Vortex line, Horse shoe vortex, Biot– Savart law, lifting line theory, effect of aspect ratio.

**UNIT III: COMPRESSIBLE FLOW THEORY 9**

Compressibility, Isentropic flow through nozzles, Normal shocks, Oblique and Expansion waves, Moving shock waves, Rayleigh and Fanno Flow, Potential equation for compressible flow, Small perturbation theory, Prandtl- Glauert Rule, Linearized supersonic flow, Method of characteristics.

**UNIT IV: AERODYNAMIC CHARACTERISTICS OF AIRFOILS, WINGS AND AIRCRAFT CONFIGURATION IN HIGH SPEED FLOWS 8**

Critical Mach number, Drag divergence Mach number, Shock stall, super critical airfoils, transonic area rule, Swept wings (ASW and FSW), Supersonic airfoils, Shock-Expansion Theory, Wave drag, Delta wings.

**UNIT V: FUNDAMENTALS OF VISCOUS FLOW THEORY 8**

Basics of viscous flow theory, Laminar and Turbulent boundary layers - Flow separation, Displacement, momentum and Energy Thickness, ,Boundary layer over flat plate, Blasius Solution, Estimation of skin friction drag in laminar and turbulent flow, The Reference Temperature Method.

**TOTAL: 45 HOURS**

**TEXT BOOK**


1. J.D. Anderson, "Fundamental of Aerodynamics", McGraw-Hill Book Co., New York, 2001.


**REFERENCES**


1. E.L. Houghton and N.B. Carruthers, "Aerodynamics for Engineering Students", Edward Arnold Publishers Ltd., London (First Indian Edition).
2. W.H. Rae and A. Pope, "Low speed Wind Tunnel Testing", John Wiley Publications.
3. Shapiro, A.H., Dynamics & Thermodynamics of Compressible Fluid Flow, Ronald Press,
4. John F. Wendt (Ed.), "Computational Fluid Dynamics An Introduction" With Contributions by John D. Anderson Jr., Joris Degroote, Gerard Degrez, Erik Dick, ´ Roger Grundmann and Jan Vierendeels.
5. Zucrow, M.J., and Anderson, J.D., Elements of gas dynamics McGraw-Hill Book Co., New York.
6. Rathakrishnan.E., Gas Dynamics, Prentice Hall of India, 4th edition,2012.

| AE4571 | AIRCRAFT STRUCTURE AND AERO ENGINE LAB | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1 |

**OBJECTIVE**

To experimentally study the unsymmetrical bending of beams, find the location of shear centre, obtain the stresses in circular discs and beams using photo elastic techniques, calibration of photo – elastic materials and to familiarize the students with various engines used in aircrafts.

| **Course Outcome – Cos** | | **Cognitive Skill** |
|---|---|---|
| CO-01 | To evaluate the Strain gauges and Photo elastic materials | E |
| CO-02 | To understand the shear Centre location for open and closed sections. | U |
| CO-03 | Analyze the Circular Disc Under Diametrical Compression | An |
| CO-04 | To remember precautions, preservation and starting procedure followed while working with aircraft engines | R |
| CO-05 | Evaluate the jet engines with propellers | E |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| **PO\CO** | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | M | M | L | L | S | M | M | L | L | S |
| **CO-02** | M | S | N | N | S | N | N | N | N | S | N | N | M |
| **CO-03** | M | L | L | M | L | L | N | L | M | L | L | N | S |
| **CO-04** | L | M | M | S | N | S | S | M | S | N | S | S | M |
| **CO-05** | S | S | L | L | L | L | M | L | L | L | L | M | M |

S-Strong, M-Medium, L-Low, N-Not Relevant

**LIST OF EXPERIMENTS (Structures)**

1. Perform the calibration of strain gauges
2. Perform the calibration of Photo Elastic Materials
3. Determine the Shear Centre Location for Open Section
4. Determine the Shear Centre Location for Closed Section
5. Determine the Stresses in Circular Disc Under Diametrical Compression

**LIST OF EXPERIMENTS (Aero Engines)**

1. Safety precautions followed while working with aircraft engines.
2. Study of Jet engine.
3. Study of propellers
4. Aircraft Engine starting procedure.
5. Aircraft Engine servicing and preservation procedure.

**TOTAL: 30 HOURS**

**EQUIPMENTS REQUIREMENTS (Structures)**

1. Strain gauges
2. Experimental setup for location of shear centre (open & closed section)
3. Diffuser transmission type Polaris cope with accessories

**LABORATORY EQUIPMENTS REQUIREMENTS (Aero Engines)**

| Sl. No | Equipment | Qty | Experiments No. |
|---|---|---|---|
| 2 | Jet Engine /Engine model | 1 | 3,8,9,10,11 |
| 4 | Propellers | 4 | 5 |
| 5 | Aircraft Maintenance tools. | 1 | 7 |

**SEMESTER II**

| SL. NO. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | AE4504 | Advanced Flight Dynamics | 3 | 0 | 0 | 3 |
| 2. | AE4505 | Advanced Computational Fluid Dynamics | 3 | 0 | 0 | 3 |
| 3. | AE4506 | Analysis of Composite Structures | 3 | 0 | 0 | 3 |
| 4. | AE4507 | Advanced Finite Element Methods | 3 | 0 | 0 | 3 |
| 5. | AE**** | Department Elective-II | 3 | 0 | 0 | 3 |
| 6. | AE**** | Department Elective-III | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 7. | AE4572 | Airframe & Composite Materials Lab | 0 | 0 | 3 | 1 |
| **TOTAL** | | | **18** | **0** | **3** | **19** |

| AE4504 | ADVANCED FLIGHT DYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**OBJECTIVE**

To understand the behaviour of airflow over bodies with particular emphasis on airfoil sections in the incompressible flow regime and advanced flight.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the basic principles of steady flight performance | U |
| CO-02 | To apply the aircraft maneuvering performance | A |
| CO-03 | Ability to analyze the static longitudinal stability and control | An |
| CO-04 | To understand and analysis the static lateral, directional stability and control | U |
| CO-05 | To apply the Rigid body equations of motion | A |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | M | M | S | M | M | N | L | M | S | L | M | L |
| **CO-02** | M | S | M | N | L | M | N | M | L | S | M | M | S |
| **CO-03** | M | M | S | S | S | L | L | M | M | M | S | M | M |
| **CO-04** | S | L | S | M | N | M | L | M | M | S | M | M | S |
| **CO-05** | S | L | S | M | M | L | N | S | M | M | M | S | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: STEADY FLIGHT PERFORMANCE 9**

Overview of Aerodynamics and ISA — Straight and level flight: thrust and power required/available, differences of propeller-driven and jet-powered airplanes, maximum speed, effects of altitude – Climb and Descent performance: climb angle and rate of climb, descent angle and rate of descent – Range, endurance of propeller driven and jet powered airplanes.

**UNIT II: MANEUVERING PERFORMANCE 8**

Level turn – maximum producible load factor – fastest and tightest turn – Vertical maneuver: pull- up and pull-out, pull-down – gust V-n diagram –Take off and landing performance.

**UNIT III: STATIC LONGITUDINAL STABILITY AND CONTROL 10**

Static equilibrium and stability – Pitch stability of conventional and canard aircraft – control fixedneutral point and static margin – effect of fuselage and running propellers on pitch stability – control surface hinge moment – control free neutral point – limit on forward CG travel –maneuverstability: Pull — up & level turn — control force and trim tabs — control force for maneuver– measurement of neutral point and maneuver point by flight tests.

**UNIT IV: STATIC LATERAL, DIRECTIONAL STABILITY AND CONTROL 9**

Yaw and side slip, effect of wing sweep, wing dihedral and vertical tail on directional stability –rudder fixed and rudder free — yaw control — rudder sizing — pedal force - dihedral effect: contribution of various components- roll control.

**UNIT V: AIRCRAFT DYNAMICS** **9**

Rigid body equations of motion - Axes systems and their significance — Euler angles — linearization of longitudinal equations – force and moment derivatives – short period and phugoidapproximations – pure pitching motion – linearization of equations for lateral – directional motion –roll, spiral and dutch roll approximations- Pure rolling- Pure yawing – Inertia coupling.

**TOTAL: 45 HOURS**

**TEXT BOOKS**

1. Houghton, E.L., and Caruthers, N.B., Aerodynamics for engineering students, Edward Arnold Publishers, 1988.
2. Perkins C.D., & Hage, R.E. Airplane performance, stability and control, Wiley Toppan, 2010.

**REFERENCES**

1. Kuethe, A.M., and Chow, C.Y., Foundations of Aerodynamics, John Wiley & Sons, Clancey,L.J.
2. Aerodynamics, Pitman, 1986.
3. Babister, A.W. Aircraft stability and response, Pergamon Press, 2013.
4. Nelson, R.C. Flight Stability & Automatic Control, McGraw-Hill, 2nd edition paperback 2017.
5. McCormic, B.W., Aerodynamics, Aeronautics & Flight Mechanics John Wiley, 1995.

| AE4505 | ADVANCED COMPUTATIONAL FLUID DYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study the flow of dynamic fluids by advanced computational methods.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the basic concepts of computational fluid mechanics. | R |
| CO-02 | To understand the concepts of Grid generation in computational fluid dynamics. | U |
| CO-03 | To analyses the concepts of Unsteady transonic flow around airfoils | An |
| CO-04 | Evaluate the concepts of panel methods in CFD analysis | U |
| CO-05 | Apply Various levels of approximation of flow equations in industries. | A |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | S | M | N | N | M | M | L | M | M | M |
| **CO-02** | M | S | L | N | L | M | S | L | L | S | S | M | S |
| **CO-03** | M | L | S | S | L | N | S | M | M | M | S | S | M |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-04** | M | L | M | M | N | L | S | S | M | S | M | M | S |
| **CO-05** | M | L | M | M | M | L | N | S | M | M | M | S | L |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: FUNDAMENTAL CONCEPTS** **10**

Introduction – Basic Equations of Fluid Dynamics-conservative & non-conservative forms – Introduction to governing equations usage in CFD codes with suitable examples.

**UNIT II: GRID GENERATION** **10**

Need for grid generation – Various grid generation techniques – Algebraic, conformal and numerical grid generation – importance of grid control functions – boundary point control – orthogonality of grid lines at boundaries. Elliptic grid generation using Laplace's equations for geometries like aerofoil and CD nozzle. Unstructured grids, Cartesian grids, hybrid grids, grid around typical 2D and 3D geometries – Overlapping grids – Grids around multi bodies.

**UNIT III: TIME DEPENDENT METHOD** **9**

Stability of solution, Explicit methods, Time split methods, Approximate factorization scheme, Unsteady transonic flow around airfoils. Some time dependent solutions of f l u i d dynamic problems – Navier stroke's equation.

**UNIT IV: PANEL METHODS** **8**

A brief description of source, sink and vortex flows – Application of panel methods – Methodology involved in implementing panel methods – Source panel method and its implementation - Solution methods for solving a set of large number of algebraic equations and their applications for panel methods — Solution example of flow over a circular cylinder — Vortex panel method and its implementation — Vortex lattice method.

**UNIT V: CFD FOR INDUSTRIAL APPLICATIONS** **8**

Various levels of approximation of flow equations, turbulence modeling for viscous flows, verification and validation of CFD code, application of CFD tools to 2D and 3D configurations.Unsteady flows – Grid movement method, Oscillating – Commercial CFD – CFD ++ and Fluent software.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. T. J. Chung, "Computational Fluid Dynamics", Second Edition, Cambridge University Press, 2014.
1. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.
2. A.A. Hirsch, 'Introduction to Computational Fluid Dynamics", McGraw-Hill, 1989.


**REFERENCES**


1. Wirz, HJ &Smeldern, JJ, "Numerical Methods in Fluid Dynamics", McGraw-Hill & Co., 1978.
2. Suhas V. Patankar, "Numerical Heat Transfer and Fluid Flow", CRC Press, 1980.
3. John D Anderson Jr., 'Computational Fluid Dynamics – The Basics with Applications', McGraw-Hill Education, New York, 2007.
4. Fletcher, C.A.J., "Computational Techniques for Fluid Dynamics", Vol. 1 and Vol. 2, Second Edition, Springer-Verlag, Berlin, 2013.

5. Charles Hirsch, "Numerical Computation of Internal and External Flows", Vols. 1 and 2, Second Edition, John Wiley and Sons, New York, 2007.
6. John F. Wendt (Editor), "Computational Fluid Dynamics: An Introduction", Third Edition, Springer-Verlag, Berlin, 2008.
7. Bose. TK, "Numerical Fluid Dynamics",Narosa Publishing House, 2001.

| AE4506 | ANALYSIS OF COMPOSITE STRUCTURES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study the flow of dynamic fluids by advanced computational methods and impart the knowledge on the macro mechanics of composite materials.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Remember and Understand the basic of composites and stress strain relation and fibers, matrices and fabrication. | R |
| CO-02 | Evaluate the micromechanics of unidirectional composites. | E |
| CO-03 | Analysis of micromechanics of composites. | An |
| CO-04 | Understand and evaluate the various laminated composites. | E |
| CO-05 | Understanding various laminated plates and beams. | A |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | S | S | L | S | S | N | L | L | L | S | N | S |
| **CO-02** | M | S | M | S | S | M | N | M | L | L | S | M | S |
| **CO-03** | N | M | S | L | L | S | M | M | L | L | M | L | S |
| **CO-04** | L | L | S | M | M | N | N | L | L | L | M | L | S |
| **CO-05** | N | L | N | M | S | S | N | L | L | L | S | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: FIBERS, MATRICES, AND FABRICATION METHODS 9**

Production & Properties of Glass, Carbon and Aramid Fibers – Thermosetting and Thermoplastic Polymers — Polymer Properties of Importance to the Composite, Summary of Fabrication Processes – Scope of Composite Materials for Various Aerospace Application.

**UNIT II: MICROMECHANICS OF A UNIDIRECTIONAL COMPOSITE 9**

Volume and Weight Fractions in a Composite Specimen — Longitudinal Behaviour of Unidirectional Composites – Load Sharing – Failure Mechanism and Strength – Factors Influencing Longitudinal Strength and Stiffness – Transverse Stiffness· and Strength – Prediction of Elastic Properties Using Micromechanics –Typical Unidirectional

Fiber Composite Properties – Minimum and Critical Fiber Volume Fractions.

**UNIT III: MACROMECHANICS APPROACH 9**

Stress Analysis of an Orthotropic Lamina-Hooke's Law-Stiffness and Compliance Matrices - Specially Orthotropic Material-Transversely Isotropic Material & Specially Orthotropic Material under Plane Stress-Determination of modulus of elasticity & Strain Transformations- Transformation of Stiffness and Compliance Matrices-Strengths of an Orthotropic Lamina Using Different Failure Theories.

**UNIT IV: ANALYSIS OF LAMINATED COMPOSITES 9**

Laminate Strains - Variation of Stresses in a Laminate - Resultant Forces and Moments - Synthesis of Stiffness Matrix - Laminate Description System - Construction and Properties of Special Laminates - Symmetric Laminates — Balanced Laminate - Cross-Ply, and Angle-Ply Laminates - Quasi-isotropic Laminates - Determination of Laminae Stresses and Strains — Determination of Hygrothermal Stresses - Analysis of Laminates after Initial Failure.

**UNIT V: ANALYSIS OF LAMINATED PLATES AND BEAMS 9**

Governing Equations For Laminated Composite Plates -- Governing Equations for LaminatedBeams -Application of Theory – Bending, Buckling and Vibration of Laminated Beams and Plates repair-Analysis of sandwich construction-AE technique.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. Calcote, L R. "The Analysis of laminated Composite Structures", Von – Noastrand Reinhold Company, New York 1998.
2. Madhujit Mukhopadhyay, Mechanics of Composite Materials and tructures, UniversityPress, 2004
3. Jones, R.M., "Mechanics of Composite Materials", McGraw-Hill, Kogakusha Ltd., Tokyo, 1985.
4. Autar K. Kaw, "Mechanics of Composite Materials", Second Edition, 2006.
5. P.K. Mallick; "Fiber- Reinforced Composites: Materials, Manufacturing and Design", CRC Press Taylors & Francis Group, Boca Raton, London. Third Edition.


**REFERENCES**


1. Agarwal, B.D., and Broutman, L.J., "Analysis and Performance of Fibre Composites", John Wiley and sons. Inc., New York, 1995.
2. Lubin, G., "Handbook on Advanced Plastics and Fibre Glass", Von Nostrand Reinhold Co., New York, 1989.
3. Allen Baker, "Composite Materials for Aircraft Structures", AIAA Series, 2nd Edition, 2004.
4. Calcote, LR, "The Analysis of laminated Composite Structures", Von — Nostrand ReinholdCompany, New York, 1998.
5. Isaac M. Daniel &OriIshai ,"Mechanics of Composite Materials", OUP USA publishers, 2ndedition, 2005.


| AE4507 | ADVANCED FINITE ELEMENT METHODS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce the concept of numerical analysis of structural components

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To obtain an understanding of the fundamental theory of FEA method. | R |
| CO-02 | To understand the use of basic finite elements for structural applications using truss, beam, frame and plane elements. | A |
| CO-03 | Able to apply suitable boundary conditions to a global equation for bars, beams, truss, axisymmetric problems. | An |
| CO-04 | To understand the concept of vibration and buckling. | A |
| CO-05 | To understand the application and use of FE method for heat transfer and fluid mechanics problems. | E |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-k | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | M | M | M | N | N | N | S | S | S | N |
| **CO-02** | S | S | S | M | L | N | N | N | N | M | M | L | M |
| **CO-03** | M | M | S | S | L | L | N | N | N | S | S | L | M |
| **CO-04** | L | S | S | M | N | L | N | N | N | M | M | M | M |
| **CO-05** | L | L | M | N | L | N | N | N | N | N | M | L | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION** **9**

Review of various approximate methods – Rayleigh-Ritz, Galerkin and Finite Difference Methods - Stiffness and flexibility matrices for simple cases - Basic concepts of finite element method - Formulation of governing equations and convergence criteria.

**UNIT II: DISCRETE ELEMENTS** **9**

Use of bar, Truss and beam elements for static, dynamic and structural analysis – Bar of varying section.

**UNIT III: CONTINUUM ELEMENTS** **9**

Different forms of 2-D elements and their applications for plane stress, plane strain and axisymmetric problems – CST Element – LST Element - Consistent and lumped load vectors. Use of local co-ordinates. Numerical integration. – 2-D formulations for scalar variable problems.

**UNIT IV: TORSION & BUCKLING** **9**

Formulation of the Mass and Stiffness Element Matrices for Torsion Problems – Bar and Beam Elements – Derivation of the Governing Equation – Natural Frequencies and Modes – Damping Considerations –Harmonic Response – Response Calculation Using Numerical Integration – Buckling of Columns – Problem Formulation – Solution – Determination of Buckling Loads and Modes.

**UNIT V: HEAT TRANSFER & FLUID MECHANICS PROBLEMS 9**

One Dimensional Heat Transfer Analysis – Formulation of the Governing Equations in Finite Element Form – Equivalent Load Vector – Solution & Temperature Distribution – Finite ElementFormulation & Solution for Sample Problems Involving Fluid Mechanics.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. Segerlind,L.J. "Applied Finite Element Analysis", Second Edition, John Wiley and Sons Inc., New York, 1991.
2. Tirupathi R. Chandrupatla and Ashok D. Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall, Third Edition, 2003
3. S.S.Rao, "Finite Element Method in Engineering", Butterworth, Heinemann Publishing, 3rd Edition, 1998


**REFERENCES**


1. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley & Sons, 2002.
2. K.J. Bathe and E.L. Wilson, "Numerical Methods in Finite Elements Analysis", Prentice Hall of India Ltd., 1983.
3. C.S. Krishnamurthy, "Finite Elements Analysis", Tata McGraw-Hill, 1987
4. P.Seshu, "Textbook of Finite Element Analysis"-PHI, 2004.
5. J.N.Reddy, "Finite Element Method"- McGraw -Hill International Edition. Bathe K J. Finite Elements Procedures, PHI.
6. Cook R. D., et al. "Concepts and Application of Finite Elements Analysis"- 4th Edition, Wiley & sons, 2003.


| AE4572 | AIRFRAME & COMPOSITE MATERIALS LAB | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 1 |

**OBJECTIVE:**

To introduce the concept of wood repair processes such as sheet metal forming and wood gluing and various advanced welding processes such as MIG, TIG and Plasma Arc welding.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To make the students understand the methods of composite repair such as riveting | U |
| CO-02 | To demonstrate the various methods of welding | A, |
| CO-03 | To understand and evaluate the various types of damages and repair in the composite materials | E |
| CO-04 | To demonstrate the various advanced welding processes such as MIG,TIG and Plasma Arc welding | A |
| CO-05 | To demonstrate metal and wood repair processes such as sheet metal forming and wood gluing | E |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO-01 | M | S | S | L | S | L | N | L | N | L | S | L | S |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-02** | M | S | S | M | S | L | N | L | N | L | S | L | S |
| **CO-03** | M | S | S | L | S | L | N | L | N | L | S | L | S |
| **CO-04** | M | S | S | M | S | L | N | L | N | L | S | L | S |
| **CO-05** | M | S | S | M | S | L | N | L | N | L | S | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**LIST OF EXPERIMENTS**

1. Aircraft wood gluing – single scarf joint
2. Aircraft wood gluing – Double scarf joint
3. Study of MIG, TIG and PLASMA Welding of aircraft components
4. Butt joints.
5. Riveted Joints
6. Riveted patch repairs.
7. Fabric Patch repair
8. Preparation of Epoxy/Glass fiber composite Laminates and Specimens as per ASTM standards.
9. Preparation of hybrid composites by hand lying.
10. Preparation of Sandwich panel and Specimens as per ASTM standards.
11. Repair of composites

**TOTAL: 30 HOURS**

**LIST OF EQUIPMENT**

| Sl.No. | Name of the Equipment | Quantity |
|---|---|---|
| 1 | Shear cutter pedestal type | 1 |
| 2 | Drilling Machine | 1 |
| 3 | Bench Vices | 1 |
| 4 | Radius Bend bars | 1 |
| 5 | Pipe Flaring Tools | 1 |
| 6 | Carbide Gas Plant | 1 |
| 7 | MIG Weld Plant | 1 |
| 8 | TIG Weld Plant | 1 |
| 9 | Glass Fiber and Epoxy Resin | 1 |
| 10 | Strain Gauges and strain indicator | 1 |

**SEMESTER III**

| **SL. NO.** | **COURSE CODE** | **COURSE TITLE** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|---|
| **THEORY** | | | | | | |
| 1. | AE**** | Department Elective-IV | 3 | 0 | 0 | 3 |
| 2. | AE***** | Department Elective-V | 3 | 0 | 0 | 3 |
| 3. | XXXX | Open Elective | 3 | 0 | 0 | 3 |
| **PRACTICAL** | | | | | | |
| 4. | AE45P1 | Project work Phase I | 0 | 0 | 18 | 6 |
| **TOTAL** | | | **9** | **0** | **18** | **15** |

| AE45P1 | PROJECT WORK PHASE-I | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 18 | 6 |

**OBJECTIVE**

The objective of the project work is to enable the students individually perform a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. Six periods per week shall be allotted in the time table and this time shall be utilized by the students to receive the directions from the guide, on library reading, laboratory work, computer analysis or field work as assigned by the guide and also to present in periodical seminars on the progress made in the project. Each student shall finally produce a comprehensive report covering background information, literature survey, problem statement, project work details and conclusion. This final report shall be typewritten form as specified in the guidelines.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Demonstrate a sound technical knowledge of their selected project topic. | S |
| CO-02 | Undertake problem identification, formulation and solution. | S |
| CO-03 | Design engineering solutions to complex problems utilising a systems approach. | S |
| CO-04 | Conduct an engineering project | S |
| CO-05 | Demonstrate the knowledge, skills and attitudes of a professional engineer. | S |

R - Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | L | S | S | N | N | N | L | S | S | S |
| **CO-02** | M | S | M | S | S | M | N | N | N | L | S | M | S |
| **CO-03** | L | M | L | L | L | S | N | N | N | L | L | L | S |
| **CO-04** | M | L | S | M | M | N | N | N | N | L | M | L | S |
| **CO-05** | L | L | N | M | S | S | N | N | N | L | S | L | S |

S - Strong, M- Medium, L-Low, N- Not Relevant

**SEMESTER – IV**

| SL. No. | COURSE CODE | COURSE TITLE | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45P5 | Project work Phase II | 0 | 0 | 32 | 16 |
| **TOTAL** | | | **0** | **0** | **32** | **16** |

| AE45P5 | PROJECT WORK PHASE-II | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 32 | 16 |

**OBJECTIVE**

The objective of the project work is to do project individually on a project involving theoretical and experimental studies related to the branch of study. Every project work shall have a guide who is the member of the faculty of the institution. There are 32 periods per week shall be allotted in the time table and this time shall be utilized by the students to receive the directions from the guide, on library reading, laboratory work, computer analysis or field work as assigned by the guide and also to present in periodical seminars on the progress made in the project.Each student shall finally produce either own conference certificate or own proceedings or own published papers related to project in national or international journals. A final report covering covering background information, literature survey, problem statement, project work details and conclusion shall be typewritten form as specified in the guidelines.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Demonstrate a sound technical knowledge of their selected project topic. | S |
| CO-02 | Undertake problem identification, formulation and solution. | S |
| CO-03 | Design engineering solutions to complex problems utilising a systems approach. | S |
| CO-04 | Conduct an engineering project | S |
| CO-05 | Demonstrate the knowledge, skills and attitudes of a professional engineer. | S |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO - H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | L | S | S | N | N | N | L | S | S | S |
| **CO-02** | M | S | M | S | S | M | N | N | N | L | S | M | S |
| **CO-03** | L | M | L | L | L | S | N | N | N | L | L | L | S |
| **CO-04** | L | L | S | M | M | N | N | N | N | L | M | L | S |
| **CO-05** | L | L | N | M | S | S | N | N | N | L | S | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

## DEPARTMENT ELECTIVES

## LIST OF DEPARTMENTELECTIVES
## SEMESTER I

| SL. NO | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45A1 | Theory of Vibrations | 3 | 0 | 0 | 3 |
| 2. | AE45A2 | Rocketry and Space Mechanics | 3 | 0 | 0 | 3 |
| 3. | AE45A3 | Wind tunnel Techniques | 3 | 0 | 0 | 3 |
| 4. | AE45A4 | Experimental Stress Analysis | 3 | 0 | 0 | 3 |
| 5. | AE45A5 | Aircraft Design | 3 | 0 | 0 | 3 |

## SEMESTER II

| Sl. NO | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45A6 | High Speed Jet Flows | 3 | 0 | 0 | 3 |
| 2. | AE45A7 | Hypersonic Aerodynamics | 3 | 0 | 0 | 3 |
| 3. | AE45A8 | Advanced Propulsion Systems | 3 | 0 | 0 | 3 |
| 4. | AE45A9 | Advanced Heat Transfer | 3 | 0 | 0 | 3 |
| 5. | AE45B1 | Experiments Methods in Fluid Mechanics | 3 | 0 | 0 | 3 |
| 6. | AE45B2 | Airworthiness and Air Regulations | 3 | 0 | 0 | 3 |
| 7. | AE45B3 | Aircraft Systems Engineering | 3 | 0 | 0 | 3 |

## SEMESTER III

| SI. NO | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | AE45B4 | Aero Elasticity | 3 | 0 | 0 | 3 |
| 2. | AE45B5 | Theory of boundary layers | 3 | 0 | 0 | 3 |
| 3. | AE45B6 | Smart Materials and Structural Health Monitoring | 3 | 0 | 0 | 3 |
| 4. | AE45B7 | Gas Dynamics | 3 | 0 | 0 | 3 |
| 5. | AE45B8 | Fatigue and Fracture Mechanics | 3 | 0 | 0 | 3 |
| 6. | AE45B9 | Avionics | 3 | 0 | 0 | 3 |

| AE45A1 | THEORY OF VIBRATIONS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

Students will get the detailed knowledge about the analysis of vibration

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Understand the free, forced, damped, un damped and vibration measuring instrument | U |
| CO-02 | Calculate natural frequency for two Degrees and Multi degrees of Freedom Systems | An |
| CO-03 | Apply the natural frequency of a system using approximate methods | A |
| CO-04 | Outline the application of elements of aero elasticity | R |
| CO-05 | Ability to analyze the computational technique in vibration and beam element. | A |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | M | M | L | S | L | N | L | N | L | S | L | S |
| **CO-02** | S | M | S | M | S | L | N | L | N | L | S | L | S |
| **CO-03** | M | S | L | L | S | L | N | L | N | L | S | L | S |
| **CO-04** | S | S | L | M | S | L | N | L | N | L | S | L | S |
| **CO-05** | M | S | S | M | S | L | N | L | N | L | S | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: SINGLE DEGREE OF FREEDOM SYSTEMS 10**

Introduction to simple harmonic motion, D'Alembert's Principle, Free vibrations –Damped vibrations – Forced Vibrations, with and without damping – supportexcitation – Vibration measuring instruments.

**UNIT II: MULTI DEGREES OF FREEDOM SYSTEMS 10**

Two degrees of freedom systems - Static and Dynamic couplings – vibrationabsorber- Principal co-ordinates - Principal modes and orthogonal condition – Eigenvalue problems - Hamilton's principle - Lagrangean equations and application.

**UNIT III: CONTINUOUS SYSTEMS & APPROXIMATE METHODS 9**

Vibration of elastic bodies - Vibration of strings - Longitudinal - Lateral and TorsionalVibration, Approximate methods - Rayleigh's method - Dunkerlay's method – Rayleigh-Ritz method, Matrix Iteration method.

**UNIT IV: ELEMENTS OF AEROELASTICITY 8**

Vibration due to coupling of bending and torsion - Aeroelastic problems – Collarstriangle - Wing Divergence - Aileron Control reversal – Flutter – Buffeting.

**UNIT V: SOLUTION METHOD** **8**

Computational technique in vibration, Vibrating string, General method, Beam element, Global matrices, Transformation of matrices, Equation of motion of complete system, Consistent and Lombard mass.

**TOTAL: 45 HOURS**

**TEXT BOOKS**

1. Thomson W T, 'Theory of Vibration with Application' - CBS Publishers, 1990.
2. G.K.Grover, "Mechanical Vibrations", 7th Edition, Nem Chand Brothers, Roorkee,India, 2003.

**REFERENCES**

1. Timoshenko S., Vibration Problems in Engineering – John Wiley and Sons, NewYork, 1993.
2. Bisplinghoff R.L., Ashely H and Hogman R.L., Aeroelasticity – Addision WesleyPublication, New york, 1983.
3. William W Seto, 'Mechanical Vibrations' – McGraw Hill, Schaum Series.
4. TSE. F.S., Morse, I.F., Hunkle, R.T., Mechanical Vibrations – Prentice Hall,New York, 1984.
5. Leonard Meirovitch, 'Elements of Vibration Analysis' – McGraw Hill InternationalEdition Clarence W DeSilva, `Vibration – Fundamentals and Practice', CRCPress, Special Indian Edition, 2005.

| AE45A2 | ROCKETRY AND SPACE MECHANICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

Students will get the detailed knowledge about the multi staging rockets and satellite technology.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the concept of orbital mechanics | U |
| CO-02 | Apply the mathematical concept in satellite dynamics. | A |
| CO-03 | Apply the rocket motion in gravitational field. | A |
| CO-04 | Analyze the importance of rocket aerodynamics. | An |
| CO-05 | To understand and interpret the principles in staging and control of rocket vehicles. | R |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | L | N | L | N | L | N | N | N | N | M | L | M |
| **CO-02** | S | S | S | M | S | L | N | L | N | L | S | L | S |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-03** | S | S | L | L | M | L | N | L | N | L | M | L | S |
| **CO-04** | S | S | M | M | S | L | N | L | N | L | S | L | M |
| **CO-05** | M | S | M | M | M | L | N | L | N | L | L | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: ORBITAL MECHANICS 9**

Description of solar system – Kepler's Laws of planetary motion – Newton's Law of Universal gravitation – Two body and Three-body problems – Jacobi's Integral, Librations points – Estimation of orbital and escape velocities.

**UNIT II: SATELLITE DYNAMICS 9**

Geosynchronous and geostationary satellites- factors determining life time of satellites – satellite perturbations – orbit transfer and examples –Hohmann orbits – calculation of orbit parameters– Determination of satellite rectangular coordinates from orbital elements- satellite epiphermis.

**UNIT III: ROCKET MOTION 9**

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

**UNIT IV: ROCKET AERODYNAMICS 9**

Description of various loads experienced by a rocket passing through atmosphere – drag estimation – wave drag, skin friction drag, form drag and base pressure drag – Boat-tailing in missiles – performance at various altitudes – rocket stability – rocket dispersion – launching problems.

**UNIT V: STAGING AND CONTROL OF ROCKET VEHICLES 9**

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

**TOTAL: 45 HOURS**

**TEXT BOOK**

1. Cornelisse, JW, "Rocket Propulsion and Space Dynamics", J.W. Freeman & Co., Ltd., London, 1982.

**REFERENCES**

1. Parker, E R, "Materials for Missiles and Spacecraft", McGraw-Hill Book Co., Inc., 1982.
2. Van de Kamp, "Elements of Astromechanics", Pitman Publishing Co., Ltd., London, 1980.
3. Suresh. B N & Sivan. K, "Integrated Design for Space Transportation System", Springer India, 2016.
4. Sutton, GP, Biblarz, O, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 9th Edition, 2017.

| AE45A3 | WIND TUNNEL TECHNIQUES | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To provide extensive treatment of the operating principles and limitations of pressure and temperature measurements.
- To cover both operating and application procedures of hot wire anemometer.
- To describe flow visualization techniques and to highlight in depth discussion of analogue methods.

| Course Outcome - COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the fundamental measurements in fluid mechanics. | U |
| CO-02 | To analyze the wind tunnel measurements. | An |
| CO-03 | Synthesis the flow visualization and analogue methods. | S |
| CO-04 | To evaluate pressure, velocity and temperature measurements. | E |
| CO-05 | To understand the special flows and uncertainty analysis | U |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | L | L | M | M | L | N | M | N | M | S | L | L |
| **CO-02** | L | S | S | M | S | L | N | L | N | L | S | L | M |
| **CO-03** | M | S | S | L | S | L | N | L | N | L | S | L | M |
| **CO-04** | S | S | S | M | M | L | N | L | N | L | S | L | M |
| **CO-05** | M | S | S | M | S | L | N | L | N | L | S | L | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: BASIC MEASUREMENTS IN FLUID MECHANICS** **7**

Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization – Components of measuring systems – Importance of model studies.

**UNIT II: WIND TUNNEL MEASUREMENTS** **10**

Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation and calibration of wind tunnels – Turbulence- Wind tunnel balance – Wire balance – Strut-type – Platform-type – Yoke-type – Pyramid type – Strain gauge balance – Balance calibration.

**UNIT III: FLOW VISUALIZATION AND ANALOGUE METHODS 9**

Visualization techniques – Smoke tunnel – Hele-Shaw apparatus - Interferometer – Fringe-Displacement method – Schlieren system – Shadowgraph - Hydraulic analogy – Hydraulic jumps – Electrolytic tank.

**UNIT IV: PRESSURE, VELOCITY AND TEMPERATURE MEASUREMENTS 9**

Pitot - static tube characteristics - Velocity measurements - Hot-wire anemometry – Constant current and Constant temperature Hot-Wire anemometer – Pressure measurement techniques - Pressure transducers – Temperature measurements.

**UNIT V: SPECIAL FLOWS AND UNCERTAINTY ANALYSIS 10**

Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers - Data acquisition and processing – Signal conditioning – Uncertainty analysis – Estimation of measurement errors – External estimate of the error – Internal estimate of the error – Uncertainty calculation - Uses of uncertainty analysis.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. Rathakrishnan, E., "Instrumentation, Measurements, and Experiments in Fluids," CRC Press – Taylor & Francis, 2007.
2. Robert B Northrop, "Introduction to Instrumentation and Measurements", Second Edition, CRC Press, Taylor & Francis, 2006.


**REFERENCES**


1. Bradsaw "Experimental Fluid Mechanics", Elsevier, 2nd edition, 1970.
2. Pope, A., and Goin, L., "High Speed Wind Tunnel Testing", John Wiley, 1985.


| AE45A4 | EXPERIMENTAL STRESS ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To bring awareness on experimental method of finding the response of the structure to different types of load.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | To explain the measurement of strain under static and dynamic loads and optical, pneumatic and electrical strain gauges for strain measurement. | U |
| CO-02 | To describe the Strain gauge and transducers for measurement of static and dynamic loads | R |
| CO-03 | To understand the principle of photo elastic techniques. | U |
| CO-04 | To analyze the principle of nondestructive testing | An |
| CO-05 | To describe the Fundamentals of non destructive techniques. | U |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | S | M | M | S | N | S | N | N | M | L | L | S |
| **CO-02** | S | M | S | M | S | L | N | L | N | L | S | L | S |
| **CO-03** | M | S | S | L | S | L | N | L | N | L | S | L | M |
| **CO-04** | M | M | S | M | M | L | N | L | N | L | S | L | M |
| **CO-05** | L | S | S | M | S | L | N | L | N | L | S | L | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION** **9**

Extensometers – Types – Mechanical, Electrical, Electronic and Optical – Review of bridge circuits.

**UNIT II: STRAIN GAUGE TECHNIQUES** **9**

Strain gauge and transducers for measurement of static and dynamic loads – Instrumentation, measurement and recording systems.

**UNIT III: STRAIN-GAGE CIRCUITS & INSTRUMENTATION** **9**

The Potentiometer Circuit and Its Application to Strain Measurement – Variants From The Basic Potentiometer Circuit – Circuit Output – The Wheatstone Bridge Constant Current and Constant Voltage Circuits – Circuit Sensitivity – Calibrating Strain-Gage Circuits –Effects of Lead Wires and Switches – Electrical Noise Reduction – Strain Measurement in Bars, Beams and Shafts.

**UNIT IV: PHOTO ELASTIC TECHNIQUES** **9**

Stress analysis by two- and three-dimensional photo elasticity – Interpretation of stress patterns – Typical applications – Description and users of reflection polariscope.

**UNIT V: NON – DESTRUCTIVE TESTING** **9**

Fundamentals of NDT. Radiography, ultrasonic, Holography, Laser holography magnetic particle inspection, fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique, Moire fringes — Grid methods.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. J.W. Dally and M.F. Riley, “Experimental Stress Analysis”, McGraw-Hill Book Co., New York, 1988.
2. Srinath,L.S., Raghava,M.R., Lingaiah,K. Gargesha,G.,Pant B. and Ramachandra,K. – Experimental Stress Analysis, Tata McGraw Hill, New Delhi, 1984
3. P. Fordham, “Non-Destructive Testing Techniques” Business Publications, London, 1988.


**REFERENCES**


1. M. Hetenyi, “Handbook of Experimental Stress Analysis”, John Wiley & Sons Inc., New York, 1980.
2. G.S. Holister, “Experimental Stress Analysis, Principles and Methods”, Cambridge University Press, 1987.
3. A.J. Durelli and V.J. Parks, “Moire Analysis of Strain”, Prentice Hall Inc., Englewood Cliffs, New Jersey, 1980.

4. Albert S. Kobayashi,"Handbook on Experimental Mechanics", Prentice Hall Publishers, 1987.
5. James W. Dally & William F. Riley, "Experimental Stress Analysis", McGraw-Hill College,1991.
6. James F. Doyle & James W. Phillips, "Manual on Experimental Stress Analysis", 5th Edition,Society for Experimental Mechanics, 1989.
7. Sharpe Jr& William N, Springer, "Handbook of Experimental Solid Mechanics", Springer,2008.
8. Udpa. S.S & Patrick O. Moore, "Non-destructive Testing Handbook", Electromagnetic Testing,Third Edition: Volume 5, 2004.

| AE45A5 | AIRCRAFT DESIGN | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To make the students familiar with the designing of an aircraft and introduce and develop the basic concept of aircraft design.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Identify the power plant and the procedures for the propeller configuration. | U |
| CO-02 | Solve the calculations of takeoff, landing, gliding and manoeuvring flight. | An |
| CO-03 | Knowledge about the estimation of static and dynamic stability analysis. | A |
| CO-04 | Be clear in design of new prototype of aircrafts and able to present new layout or plan. | R |
| CO-05 | Understand the various designs of wings, fuselage and other aircraft parts with good knowledge about the aircraft materials. | U |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | L | M | S | M | N | S | L | M | M | N | M | L | M |
| **CO-02** | S | N | S | L | S | M | N | S | L | N | M | N | M |
| **CO-03** | M | L | M | N | N | M | L | M | N | N | M | S | M |
| **CO-04** | S | M | L | S | L | S | N | L | S | L | S | N | M |
| **CO-05** | M | S | L | L | N | M | L | L | L | N | M | S | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: PRELIMINARY CONCEPTS** **9**

Aircraft Design Requirements - Specifications - Role of user - Aerodynamic and Structural considerations - Importance of weight fractions - Airworthiness requirements and standards - Classification of airplanes - Special features of an airplane- Airplane performance aspects - Initial Airplane layout – Three view drawings – Take-off weight.

**UNIT II: AIRCRAFT PERFORMANCE DESIGN 9**

Selection of geometric and aerodynamic parameters – Weight estimation and balance diagram – Drag estimation of complete aircraft – Level flight, climb, take – off and landing calculations – range and endurance.

**UNIT III: AIRCRAFT STABILITY DESIGN 9**

Static and dynamic stability estimates – control requirements. Maximum range of climb, shallow angle of climb, High Lift devices

**UNIT IV: SPECIAL PROBLEMS & PROPULSION DESIGN 9**

Layout peculiarities of subsonic and supersonic aircraft – optimisation – of wing loading to achieve desired performance – loads on undercarriages and design requirements. Characteristics of different types of power plants – Propeller characteristics and selection – Relative merits of location of power plant.

**UNIT V: AIRPLANE STRUCTURES AND MATERIALS 9**

General types of construction, Monocoque, semi-monocoque and geodesic construction, Typical wing and fuselage structure. Metallic and non-metallic materials, Use of aluminium alloy, titanium, stainless steel and composite materials – Introduction to high temperature materials. Materials for modern aircraft – Methods of analysis, testing and fabrication.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. Raymer, D.P. Aircraft conceptual Design, AIAA series, 5th edition, 2012. 2. Torenbeck, E. Synthesis of Subsonic Airplane Design, Delft University Press, U.K. 1986.
2. G. Corning, "Supersonic & Subsonic Airplane Design", II Edition, Edwards Brothers Inc., Michigan, 1953.
3. E.F. Bruhn, "Analysis and Design of Flight Vehicle Structures", Tristate Offset Co., U.S.A., 1980.
4. A.A. Lebedenski, "Notes on airplane design", Part-I, I.I.Sc., Bangalore, 1971.
5. Anderson, J.D "Aircraft Performance and Design" McGraw Hill Education; 1 edition, 2017


**REFERENCES**


1. E. Torenbeek, "Synthesis of Subsonic Airplane Design", Delft University Press, London, 1976.
2. D.P. Raymer, "Aircraft conceptual design", AIAA Series, 1988.
3. H.N.Kota, "Integrated design approach to Design fly by wire" Lecture notes Interline Pub. Bangalore, 1992.
4. S.C. Keshu & K.K. Ganapathi "Aircraft Production Techniques and Management", 1995.
5. Perkins C.D., & Hage, R.E, "Airplane performance, stability and control", Wiley Toppan, 1974.


| AE45A6 | HIGH SPEED JET FLOWS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce and develop the basic concept of high velocity jet flow.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the fundamentals of jet flows. | U |
| CO-02 | To evaluate Computational and Experimental Techniques for Studying the Jets. | E |
| CO-03 | To apply mathematical Knowledge of active jet control methods. | A |
| CO-04 | To evaluate mathematical techniques in passive jet control methods. | E |
| CO-05 | To understand the fundamentals of jet acoustics. | U |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | M | M | N | N | N | N | N | M | L | S | S |
| **CO-02** | L | M | S | M | S | L | M | L | N | L | S | L | S |
| **CO-03** | S | S | S | L | S | L | M | N | N | L | L | S | M |
| **CO-04** | M | M | N | S | M | L | M | L | N | L | S | L | M |
| **CO-05** | S | L | M | M | S | L | M | M | N | L | S | M | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION** **9**

Properties of Turbulent Jets-Fundamental Concepts, Submerged Jets- Velocity Profiles in a Submerged Jet- Spread of a turbulent submerged jet- Lines of Constant Velocity in a Submerged Jet. Velocity Variation along the Axis of a Submerged jet, Velocity, Temperature, and Concentration Profiles in a Turbulent Jet Spreading into an External Stream of Fluid- Spread of a Turbulent Jet into a Co-flowing or Counter-flowing External Stream- Turbulence Characteristics in a Free Jet.

**UNIT II: JETS** **9**

Types of Jets-Plane free-jets. Round jets. Plane jets in a co-flowing stream. Round jet in Co flowing stream- Swirling jets-Radial jets- Wall jets- Jet Characteristics & Entrainment, Mathematical treatment of jet profiles- Semi-empirical Theories. Mixing Layers- Computational and Experimental Techniques for Studying the Jets.

**UNIT III: ACTIVE JETCONTROL METHODS** **9**

Active control methods- Actuators-Fluidic, Thermal, Acoustic, Piezoelectric, Electromagnetic, MEMS, Synthetic Jets, Controls and Sensors, Applications.

**UNIT IV: PASSIVE JET CONTROL METHODS** **9**

Passive control techniques- Tabs, Grooves, Chevrons, non-circular nozzles, Notches & wires, vortex generators. Optical Flow Visualization, Applications.

**UNIT V: JET ACOUSTICS** **9**

Introduction to Jet Acoustics – Types of jet noise – Source of generation- Travelling wave solution, standing wave solution – multi-dimensional acoustics-Theoretical Concepts of Jet Noise Generation and Suppression–Jet Noise suppression techniques – applications

**TOTAL: 45 HOURS**

**TEXT BOOK:**

1. Rathakrishnan E., "Gas Dynamics", Prentice Hall of India, New Delhi, 5th edition, 2014.

**REFERENCES:**

1. Ethirajan Rathakrishnan, "Applied Gas Dynamics", John Wiley, New York, 2010.
2. Liepmann and Roshko, "Elements of Gas Dynamics", Dover Publishers, 2017.
3. Shapiro, AH, "Dynamics and Thermodynamics of Compressible Fluid Flow, Vols. I &II", Ronald Press, New York, 1953.

| AE45A7 | HYPERSONIC AERODYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce fundamental concepts and features peculiar to hypersonic flow to students to familiarize them with the aero dynamical aspects of hypersonic vehicles and the general hypersonic flow theory.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the differences between hypersonic aerodynamics and supersonic aerodynamics. | U |
| CO-02 | To describe the simple solution methods for hypersonic inviscid flows | R |
| CO-03 | To analyze the equations of boundary layer of hypersonic flow theory | An |
| CO-04 | To evaluate the viscous interactions in hypersonic flows | E |
| CO-05 | To describe the high temperature effects in hypersonic flows | S |

R-Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-k | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | M | S | L | M | S | L | L | N | S | L | L | M |
| **CO-02** | M | S | M | S | S | L | N | L | N | L | S | L | M |
| **CO-03** | S | M | S | M | S | M | N | L | N | L | S | L | S |
| **CO-04** | S | M | S | M | M | S | N | L | N | L | S | L | S |
| **CO-05** | M | L | S | S | S | L | N | L | N | L | S | L | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: FUNDAMENTALS OF HYPERSONIC AERODYNAMICS** **9**

Introduction to hypersonic aerodynamics – differences between hypersonic aerodynamics and supersonic aerodynamics - concept of thin shock layers and entropy layers – hypersonic flight

paths – hypersonic similarity parameters – shock wave and expansion wave relations of inviscid hypersonic flows.

**UNIT II: SIMPLE SOLUTION METHODS FOR HYPERSONIC INVISCID FLOWS9**
Local surface inclination methods – Newtonian theory – modified Newtonian law – tangent wedge and tangent cone and shock expansion methods – approximate methods - hypersonic small disturbance theory – thin shock layer theory.

**UNIT III: VISCOUS HYPERSONIC FLOW THEORY 9**
Boundary layer equations for hypersonic flow – hypersonic boundary layers – self similar and non self-similar boundary layers – solution methods for non-self-similar boundary layers – aerodynamic heating and its adverse effects on airframe.

**UNIT IV: VISCOUS INTERACTIONS IN HYPERSONIC FLOWS 9**
Introduction to the concept of viscous interaction in hypersonic flows - Strong and weak viscous interactions - hypersonic viscous interaction similarity parameter – introduction to shock wave boundary layer interactions.

**UNIT V: HIGH TEMPERATURE EFFECTS IN HYPERSONIC FLOWS 9**
Nature of high temperature flows – chemical effects in air – real and perfect gases – Gibb's free energy and entropy - chemically reacting boundary layers – recombination and dissociation.

**TOTAL: 45 HOURS**

**TEXT BOOK**

1. John D. Anderson. Jr., "Hypersonic and High Temperature Gas Dynamics", Mc.Graw hill Series, New York, 1996.

**REFERENCES**

1. John D. Anderson. Jr., "Modern Compressible flow with historical Perspective", Mc.Graw Hill Publishing Company, New York, 1996.
2. John T. Bertin, "Hypersonic Aerothermodynamics", published by AIAA Inc., Washington.D.C., 1994.

| AE45A8 | ADVANCED PROPULSION SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study the detail about working and performance of gas turbine engines, ramjet and advanced rocket techniques.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the rocket propulsion systems | R |
| CO-02 | Analyze the concepts of chemical rockets | A |
| CO-03 | Understand the ramjet and scramjet propulsion system. | E |

| | | |
|---|---|---|
| CO-04 | Analyze the electric and ion propulsion systems. | U |
| CO-05 | To analyze the nuclear and solar propulsion systems. | An |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | L | S | M | M | S | L | S | N | N | L | S | L | L |
| **CO-02** | M | S | L | L | M | M | L | N | N | L | N | L | L |
| **CO-03** | M | L | S | L | M | L | L | N | N | L | N | L | N |
| **CO-04** | S | M | M | L | S | L | M | N | N | L | M | L | L |
| **CO-05** | M | S | S | L | M | M | L | N | N | M | L | L | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: ROCKET PROPULSION** **8**

Operating principle – Thrust equation of rockets - Specific impulse of a rocket – internal ballistics- Rocket nozzle contour optimization, Rocket performance considerations.

**UNIT: II: CHEMICAL ROCKETS** **10**

Solid propellant rockets – Selection criteria of solid propellants – Important hardware components of solid rockets – Propellant grain design considerations – Liquid propellant rockets – Cryogenic and semi cryogenic rockets -Selection of liquid propellants – Cooling in liquid rockets – Limitations of hybrid rockets – Relative advantages of liquid rockets over solid rockets-Propellant Combustion-Combustion Instability.

**UNIT III: RAMJETS AND SCRAMJET ENGINES** **10**

Working or Ramjet engine and its performance – Efficiencies - Preliminary performance calculations – Typical modes of inlet operation– air augmented rockets - Introduction to scramjet – Preliminary concepts in supersonic combustion – Problems encountered for designing scramjet engine - Various types of supersonic combustors.

**UNIT IV: ELECTRIC AND ION PROPULSION** **8**

Basic concepts in electric propulsion– Classification of electric rockets - Arc plasma rocket engine – Magneto plasma rocket engine - power requirements and rocket efficiency – thermal thrusters – electrostatic thrusters – plasma thruster - Ion rocket engine.

**UNIT V: NUCLEAR AND SOLAR ROCKETS** **9**

Working of Nuclear rocket engine– nuclear rocket nozzles – nuclear rocket thrust control – Nuclear thermal rocket - Working of solar rocket engine - Solar sail – Concept of nozzle less propulsion - Pulsed inductive thruster - radioisotope propulsion.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. G.P. Sutton, “Rocket Propulsion Elements”, John Wiley & Sons Inc., New York, 1998.
2. William H. Heiser and David T. Pratt, Hypersonic Airbreathing propulsion, AIAA Education Series, 2001.

3. HS Mukunda, "Understanding Aerospace Chemical Propulsion", I.K. International Publishing House Pvt. Limited, 2017.

**REFERENCES**

1. Fortescue and Stark, Spacecraft Systems Engineering, 1999.
2. Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison – Wesley Longman INC, 1999.
3. Cumpsty, Jet propulsion, Cambridge University Press, 2003.

| AE45A9 | ADVANCED HEAT TRANSFER | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce the concepts of heat transfer and application of finite element methods in heat transfer which enable the students to design components subjected to thermal loading.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the basics of heat transfer | U |
| CO-02 | Evaluate the conductive heat transfer | E |
| CO-03 | Evaluate the basic concepts of convective heat transfer | E |
| CO-04 | Understand the basic radiative heat transfer | U |
| CO-05 | Apply the finite element methods in heat transfer | A |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | L | S | N | M | S | S | S | S | M | S | S | M | S |
| **CO-02** | M | S | M | M | S | S | M | S | M | M | M | M | M |
| **CO-03** | S | M | M | M | S | S | M | M | M | S | S | M | S |
| **CO-04** | S | M | S | M | S | M | S | S | M | S | S | M | M |
| **CO-05** | S | M | S | M | S | M | S | S | M | S | S | M | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: BASICS OF HEAT TRANSFER** **9**

Basic review of heat transfer –Conduction – Fins - Convection -Radiation– Aerospace problems- Application of numerical methods.

**UNIT II: CONDUCTIVE HEAT TRANSFER** **9**

Conduction – Convection systems – Numerical treatment of 1-D and 2-D heat conduction – Problems in Cartesian and polar coordinate systems – conduction with heat generation - Heat transfer problems in infinite and semi-infinite solids – 1-D Transient analysis.

**UNIT III: CONVECTIVE HEAT TRANSFER 9**

Convection- Numerical treatment of steady 1-D and 2-d heat convection-diffusion steady-unsteady problems- Computation of thermal boundary layer flows-Transient free convection from a heat vertical plate.

**UNIT IV: RADIATIVE HEAT TRANSFER 9**

Radiation- Numerical treatment of radiation problems- transient mixed convection and radiation from a vertical fin.

**UNIT V: APPLICATIONS OF FINITE ELEMENT METHODS IN HEAT TRANSFER 9**

Finite element equation for one dimensional heat conduction equations – Heat transfer in two dimensions – Shape function derivation, stiffness matrix and load vector for heat transfer 2D element – Numerical problems

**TOTAL: 45 HOURS**

**TEXT BOOKS:**


1. P. S. Ghoshdasidar , "Computer simulation of low and Heat transfer" McGraw-Hill Book Co., Inc., New Delhi, 1998.
2. C.S. Krishnamurthy, "Finite Elements Analysis", Tata McGraw-Hill, 1987.
3. Yunus A. Cengel, Heat Transfer – A Practical Approach Tata McGraw Hill Edition, 2003
4. S.C. Sachdeva, "Fundamentals of Engineering Heat & Mass Transfer", Wiley Eastern Ltd., New Delhi, 1981.


**REFERENCES:**


1. John H. Lienhard, "A Heat Transfer Text Book", Prentice Hall Inc., 1981.
2. J.P. Holman, "Heat Transfer", McGraw-Hill Book Co., Inc., New York, 6th Edition, 1991.
3. John D. Anderson, JR" Computational Fluid Dynamics", McGraw-Hill Book Co., Inc., New York.
4. T.J. Chung, Computational Fluid Dynamics, Cambridge University Press, 2002
5. C.Y.Chow, "Introduction to Computational Fluid Dynamics", John Wiley, 1979.


| AE45B1 | EXPERIMENTAL METHODS IN FLUID MECHANICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVES**

- To learn basic principles of fluid properties measuring instruments
- To learn the rate of flow in wind tunnel.
- To learn experiments and drawing to measure the pressure, velocity & Temperature

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Understanding basic principles of fluid properties measuring instruments | U |
| CO-02 | Evaluation of the rate of flow in wind tunnel. | E |

| | | |
|---|---|---|
| CO-03 | Conducting experiments and methods in various flow visualization instruments. | S |
| CO-04 | Conducting experiments and drawing to measure the pressure, velocity & Temperature | S |
| CO-05 | Model study in data acquisition and analysis. | U |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | S | S | M | N | N | M | M | L | M | M | M |
| **CO-02** | M | S | L | N | L | M | S | L | L | S | S | M | S |
| **CO-03** | M | L | S | S | L | N | S | M | M | M | S | S | M |
| **CO-04** | M | L | M | M | N | L | S | S | M | S | M | M | S |
| **CO-05** | M | L | M | M | M | L | N | S | M | M | M | S | L |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION TO MEASUREMENTS 8**

Objective of experimental studies – Fluid mechanics measurements – Properties of fluids – Measuring instruments – Performance terms associated with measurement systems – Direct measurements - Analogue methods – Flow visualization –Components of measuring systems – Importance of model studies - Experiments on Taylor-Proudman theorem and Ekman layer – Measurements in boundary layers -

**UNIT II: WIND TUNNEL MEASEUREMENTS 8**

Characteristic features, operation and performance of low speed, transonic, supersonic and special tunnels - Power losses in a wind tunnel – Instrumentation and calibration of wind tunnels – Turbulence- Wind tunnel balance – Principle and application and uses – Balance calibration.

**UNIT III: FLOW VISUALIZATION AND ANALOGUE METHODS 10**

Visualization techniques – Smoke tunnel – Hele-Shaw apparatus - Interferometer – Fringe-Displacement method – Shadowgraph - Schlieren system – Background Oriented Schlieren (BOS) System - Hydraulic analogy – Hydraulic jumps – Electrolytic tank

**UNIT IV: MEASUREMENTS OF PROPERTIES 10**

Pressure measurement techniques- Pitot, Static, and Pitot-Static Tubes and characteristics – Pressure Sensitive Paints - Pressure transducers – Velocity measurements – Hot-wire anemometry-Constant current and Constant temperature Hot-Wire anemometer – Hot- film anemometry - Laser Doppler Velocimetry (LDV) – Particle Image Velocimetry (PIV)- Temperature measurements – Measurement of heat flux – Foil type heat flux gauge – Transient analysis of foil gauge– Thin film sensors – Slug type heat flux sensor.

**UNIT V: DATA ACQUISITION SYSTEMS 9**

Data acquisition and processing – Signal conditioning – Statistical analysis of experimental data – Regression analysis – Estimation of measurement errors – Uncertainty calculation – Uses of uncertainty analysis.

**TOTAL: 45 HOURS**

**TEXT BOOK**

1. Rathakrishnan, E., "Instrumentation, Measurements, and Experiments in Fluids," CRC Press – Taylor & Francis, 2007.

**REFERENCE**

1. Robert B Northrop, "Introduction to Instrumentation and Measurements", Second Edition, CRC Press, Taylor & Francis, 2006.

| AE45B2 | AIRWORTHINESS AND AIR REGULATIONS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To learn knowledge of certification and publication procedure, licencing and civil aviation requirements.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Understanding basic requirements of airworthiness for civil and military aircraft | U |
| CO-02 | To understand the basic concept of airworthiness | R |
| CO-03 | To know the procedure for development and test flight and Certification | U |
| CO-04 | To Identify the approved materials and licensing procedure | E |
| CO-05 | To analyze storage of various aeronautical products like rubber goods and various fluids | An |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | S | M | S | L | N | N | M | M | L | L | M | S |
| **CO-02** | L | S | S | N | L | M | S | L | L | S | S | M | S |
| **CO-03** | M | S | L | L | S | N | S | L | M | M | S | S | S |
| **CO-04** | M | L | M | M | N | L | S | L | M | S | M | M | S |
| **CO-05** | M | L | M | M | M | L | N | M | M | M | M | S | N |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION TO AIRCRAFT RULES 8**

Airworthiness requirements for civil and military aircraft – CAA, FAA, JAR and ICAO regulations – Defence standards – Military standards and specifications.

**UNIT II: BASIC CONCEPTS OF AIRWORTHINESS 9**

Privileges and responsibilities of various categories of AME license and approved persons – Knowledge of mandatory documents like certificate of Registration – Certificate of Airworthiness – Conditions of issue and validity – Export certificate of Airworthiness – Knowledge of Log Book, Journey Log Book, Technical Log Book etc.

**UNIT III: CERTIFICATION AND PUBLICATION PROCEDURES 10**

Procedure for development and test flight and Certification – Certificate of Flight release – Certificate of Maintenance – Approved Certificates – Technical Publications – Aircraft Manual – Flight Manual – Aircraft Schedules – Registration Procedure, Certification, Identification and Marking of Aircraft.

**UNIT IV: LICENSING AND MATERIAL SELECTIONS 9**

Modifications – Concessions – Airworthiness directives – Service bulletins – Crew training and their licenses – approved inspection – Approved materials – Identification of approved materials – Bonded and quarantine stores.

**UNIT V: CASE STUDIES AND CIVIL AVIATION REQUIREMENTS 9**

Storage of various aeronautical products like rubber goods and various fluids – Accident investigation procedures – Circumstances under which C of A is suspended – ICAO and IATA regulations – Chicago and Warsaw conventions – Familiarization of recent issues of Advisory Circulars – Civil Aviation Requirements Section 2 – Airworthiness.

**TOTAL: 45 HOURS**

**TEXT BOOK**

1. Gran E L and Richard Levenworth, Statistical Quality Control, 7th Edition McGraw Hill,1997

**REFERENCES**

1. Civil Airworthiness Requirements (www.dgca.nic.in), 2016.
2. Civil Aircraft Airworthiness Information and Procedures (CAP 562).
3. Civil Aviation Requirements Section 2 - Airworthiness.
4. Manual of Civil Aviation/ Organisation Manual DGCA, 2017.
5. The Indian Aircraft Act and the Rules (www.dgca.nic.in), 2008.

| AE45B3 | AIRCRAFT SYSTEMS ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To provide exposure to different fault and failure analysis methods in aircraft systems and to provide exposure on systems engineering process, System Architecture.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | Understanding basic fundamentals of Systems Engineering | U |
| CO-02 | To understand the basic concept of aircraft system and design | R |
| CO-03 | To evaluate the system architecture sand integration | E |
| CO-04 | To synthesize the practical considerations and configuration control | S |
| CO-05 | To analyze systems reliability and maintainability | An |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome.**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | L | N | M | S | M | S | N | M | S | S | M | L |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-02** | S | S | M | S | S | S | M | N | M | M | M | M | L |
| **CO-03** | M | S | M | M | S | S | M | N | S | S | S | M | M |
| **CO-04** | M | M | S | M | S | M | S | L | M | S | S | M | M |
| **CO-05** | M | S | S | M | S | M | S | L | M | S | S | M | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION TO SYSTEMS ENGINEERING 9**

Overview of Systems Engineering- Systems Engineering Concept Map-Systems Definition-The seven steps Systems Engineering-Conceptual System Design- System Engineering Process- Requirements and Management-Trade Studies-Integrated Product And Process Development.

**UNITII: THE AIRCRAFT SYSTEMS AND DESIGN 9**

Introduction- Everyday Examples of Systems- Aircraft Systems –Generic Systems-Product Life Cycle- Different Phases-Whole Life Cycle Tasks- Systems Analysis-Design Drivers in the Project, Product, Operating Environment- Interfaces with the Subsystems-Mission analysis

**UNIT III: SYSTEM ARCHITECTURE SAND INTEGRATION 9**

Introduction- Systems Architectures –Modeling and Trade-Offs Evolution of Avionics Architectures- Systems Integration Definition-Examples of Systems Integration-Integration Skills-Management of Systems Integration.

**UNIT IV: PRACTICAL CONSIDERATIONS AND CONFIGURATION CONTROL 9**

Stakeholders- Communications- Criticism- Configuration Control Process-Portrayal of a System- Varying Systems Configurations- Compatibility-Factors Affecting Compatibility– Systems Evolution. Considerations and Integration of Aircraft Systems- Risk Management.

**UNIT V: SYSTEMS RELIABILITYAND MAINTAINABILITY 9**

Systems and Components-Analysis- Influence, Economics, Design for Reliability-Fault and Failure Analysis-System Life Cycle cost-Case Study-Maintenance Types-Program-Planning and Design.

**TOTAL: 45 HOURS**

**TEXT BOOK:**


1. Andrew P.Sage& James E.Armstrong, “Introduction to Systems Engineering”, 1st edition, 2000.


**REFERENCES:**


1. Erik Aslaksen & Rod Belcher, “Systems Engineering”, Prentice Hall, 1992.
2. Ian Moir & Allan Sea bridge, “Design and Development of Aircraft Systems”, Wiley, 2nd edition, 2012.
3. Ian Moir& Allan Sea bridge, “Aircraft Systems Mechanical, electrical, and avionics subsystems integration”, John Wiley &Sons Ltd, 2011.
4. Peter. Sydenham, “Systems Approach to Engineering Design”,Artechhouse, Inc, London, 2003.


| **AE45B4** | **AERO ELASTICITY** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**OBJECTIVE**

To understand the theoretical concepts of aero elasticity and effect of elastic deformation on static longitudinal stability.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the concept of aero elastic phenomena and Influence and stiffness coefficients. | U |
| CO-02 | To apply the concept of divergence of a lifting surface with simple two dimensional idealisation. | A |
| CO-03 | To analyse and critical aileron reversal speed, aileron efficiency and Semi rigid theory and successive approximations | An |
| CO-04 | Analyse of flutter and two dimensional thin air-foils in steady incompressible flow. | An |
| CO-05 | Identify the effects of galloping of transmission lines and Flow induced vibrations of transmission lines. | U |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | S | L | M | M | S | N | L | L | N | L | L | M |
| **CO-02** | S | M | L | S | M | M | N | N | L | N | L | M | S |
| **CO-03** | S | S | S | S | L | L | N | N | L | N | L | M | M |
| **CO-04** | M | M | L | S | L | M | N | L | L | N | M | M | S |
| **CO-05** | M | M | L | S | L | L | N | L | L | N | M | M | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: AEROELASTIC PHENOMENA 6**

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

**UNIT II: DIVERGENCE OF A LIFTING SURFACE 10**

Simple two dimensional idealisations-Strip theory – Integral equation of the second kind – Exact solutions for simple rectangular wings – 'Semirigid' assumption and approximate solutions – Generalised coordinates – Successive approximations – Numerical approximations using matrix equations.

**UNIT III: STEADY STATE AEROLASTIC PROBLEMS 9**

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** **14**

Non-dimensional parameters – Stiffness criteria – Dynamic mass balancing – Dimensional similarity. Flutter analysis – Two dimensional thin airfoils in steady incompressible flow – Quasisteady 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** **6**

Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges - 1931 Transcontinental & Western Air Fokker F-10 crash – Case Study.

**TOTAL: 45 HOURS**

**TEXT BOOKS:**


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


**REFERENCES:**


1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", II Edition Addison Wesley Publishing Co., Inc., 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


| AE45B5 | THEORY OF BOUNDARY LAYERS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce the solution methods for boundary layer problems and enables the students to understand the importance of viscosity and boundary layer in fluid flow.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the concept of viscous flow and Navier-Strokes equation. | U |
| CO-02 | To analyse the concept of development of boundary layer, Displacement thickness, momentum and energy thickness. | An |
| CO-03 | To apply the concept of flow separation and get the similarity solutions | A |
| CO-04 | To understand the concept of boundary layers with pressure gradient, eddy viscosity and mixing length. | U |
| CO-05 | To analyse the methods of Boundary layer control and acceleration of boundary layer. | An |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | M | S | M | L | S | N | L | L | N | M | L | S |
| **CO-02** | M | S | M | M | L | M | N | N | L | N | S | M | M |
| **CO-03** | M | S | M | L | L | L | N | N | L | N | L | N | S |
| **CO-04** | S | S | M | S | N | M | N | L | L | N | M | M | M |
| **CO-05** | S | M | N | M | M | L | N | L | L | N | M | M | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: THEORY OF VISCOUS FLOW 8**

Fundamental equations of viscous flow, Conservation of mass, Conservation of Momentum-Navier-Stokes equations, Energy equation, Mathematical character of basic equations, Dimensional parameters in viscous flow, Non-dimensional numbers - basic equations and boundary conditions, vorticity considerations, creeping flow, boundary layer flow.

**UNIT II: INCOMPRESSIBLE VISCOUS FLOWS AND BOUNDARY LAYERS 10**

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

**UNIT III: LAMINAR BOUNDARY LAYER THEORY 10**

Laminar boundary layer equations, Flat plate Integral analysis of Karman – Integral analysis of energy equation – Laminar boundary layer equations – boundary layer over a curved body-Flow separation- similarity solutions, Blasius solution for flat-plate flow, Falkner–Skan wedge flows, Boundary layer temperature profiles for constant plate temperature –Reynold's analogy, Integral equation of Boundary layer – Pohlhausen method – Thermal boundary layer calculations.

**UNIT IV: THEORY OF TURBULENT BOUNDARY LAYER 9**

Turbulence-physical and mathematical description, Two-dimensional turbulent boundary layer equations — Velocity profiles – The law of the wall – The law of the wake – Turbulent flow in pipes and channels – Turbulent boundary layer on a flat plate – Boundary layers with pressure gradient, Eddy Viscosity, mixing length , Turbulence modelling.

**UNIT V: BOUNDARY LAYER TRANSITION AND SEPARATION 8**

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

**TOTAL: 45 HOURS**

**TEXT BOOK:**

1. White, F. M., Viscous Fluid Flow, McGraw-Hill & Co., Inc., New York, 2008.

**REFERENCES:**


1. Schlicting, H., Boundary Layer Theory, McGraw-Hill, New York, 1979.
2. Reynolds, A, J., Turbulent Flows Engineering, John Wiley and Sons, 1980.


| AE45B6 | SMART MATERIALS AND STRUCTURAL HEALTH MONITORING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce the intelligent systems and neural networks to students.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To understand the concept of structural health monitoring, smart Materials and non-destructive evaluation. | An |
| CO-02 | To understand the basic concept of electro-active materials, and Ionic Polymer Matrix Composite. | U |
| CO-03 | To apply the procedure for micro and macro-mechanics, modeling laminated composites based on classical laminated plate theory. | A |
| CO-04 | To know operational evaluation and statistical model development for feature discrimination. | E |
| CO-05 | To apply advanced smart materials and structures. | A |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | M | M | S | L | N | N | M | M | N | L | M | M |
| **CO-02** | M | M | M | N | L | M | N | S | S | N | S | M | M |
| **CO-03** | L | M | L | L | S | N | N | S | M | N | S | S | M |
| **CO-04** | M | L | M | M | N | L | N | N | N | N | M | M | M |
| **CO-05** | S | N | M | M | M | L | N | M | S | N | M | S | N |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: STRUCTURAL HEALTH MONITORING 8**

An Overview of Structural Health Monitoring, Structural Health Monitoring and Smart Materials, Structural Health Monitoring versus Non Destructive Evaluation - A broad Overview of Smart Materials - Overview of Application Potential of SHM Notable Applications of SHM – Aerospace Engineering - Structural health monitoring of composites – Repair investigation using SHM.

**UNIT II: OVERVIEW OF SMART MATERIALS 10**

Introduction to Smart Materials, Principles of Piezoelectricity, Perovskyte Piezoceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers, Principles of Magnetostriction, Rare earth Magnetostrictive materials, Giant Magnetostriction and Magneto-resistance Effect, Introduction to Electro-active Materials, Electronic Materials, Electro-active Polymers, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect,

Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids.

**UNIT III: SMART COMPOSITES 10**

Review of Composite Materials, Micro and Macro-mechanics, Modelling Laminated Composites based on Classical Laminated Plate Theory, Effect of Shear Deformation, Dynamics of Smart Composite Beam, Governing Equation of Motion, Finite Element Modelling of Smart Composite Beams , Vibration Control using SHM –introduction to FE formulation Constitutive Relationship - Element Stiffness Matrix for High Precision Finite Element -Element Mass Matrix for High Precision Finite Element - Developing Actuator and Sensor Influence Matrix .Delamination Sensing using Piezo Sensory Layer.

**UNIT IV: INTELLIGENT SYSTEMS AND NEURAL NETWORKS 9**

Operational evaluation -.Data acquisition- Feature extraction-Statistical model development for feature discrimination -Data Cleansing – Normalization-Data Fusion – Compression – Statistical model building - Supervised pattern recognition - Unsupervised pattern recognition – Signal processing – Fuzzy C means- K means – Kohenon's Self organization mapping-Fundamentals of Wavelet analysis –Life Prediction.

**UNIT V: ADVANCES IN SMART STRUCTURES & MATERIALS 8**

Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials, Autophagous Materials, Self-Healing Polymers, Intelligent System Design, Emergent System Design of Chemical and Bio- Chemical sensing in structural Assessment – Absorptive chemical sensors – Spectroscopes – Fibre Optic Chemical Sensing Systems and Distributed measurement.

**TOTAL: 45 HOURS**

**TEXT BOOKS:**


1. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, "Structural Health Monitoring", Wiley - ISTE, 2006.
2. Douglas E Adams, "Health Monitoring of Structural Materials and Components-Methods with Applications", John Wiley and Sons, 2007.


**REFERENCES:**


1. Brian Culshaw, "Smart Structures,and Materials", Artech House, 2000.
2. Gandhi and Thompson, "Smart Materials and Structures", Springer Netherlands, 1992.
3. LaureneFausett, "Fundamentals Of Neural Networks", Pearson publishers, 1994
4. Victor Giurglutiu, "Structural Health Monitoring with Wafer Active Sensors", Academic Press Inc, 2007.


| AE45B7 | GAS DYNAMICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To gain insights into the steady one-dimensional fluid flow, its model and tool to solve the fluid flow problems.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To evaluate dynamic head measurement in compressible flow and wave propagation. | E |

| | | |
|---|---|---|
| CO-02 | To analyse equations of motion for a normal shock wave. | An |
| CO-03 | To understand the concept of oblique shock wave and reflected shock wave. | U |
| CO-04 | To remember the concept of measurements in compressible flow and flow visualization in high speed wind tunnels. | R |
| CO-05 | To understand the fundamentals of rarefied and high temperature gas dynamics and slip flow transition. | U |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| **PO/CO** | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | S | L | M | M | S | N | L | M | N | M | L | M |
| **CO-02** | S | M | M | M | L | M | N | N | L | N | S | M | L |
| **CO-03** | S | S | L | L | M | L | N | N | M | N | L | N | M |
| **CO-04** | M | S | M | S | L | M | N | L | L | N | M | M | L |
| **CO-05** | S | M | N | M | M | L | N | L | L | N | S | M | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: STEADY ONE-DIMENSIONAL FLOW** **10**

Thermodynamics of Fluid Flow – First Law of Thermodynamics - The Second Law of Thermodynamics - Thermal and Calorical Properties – Perfect Gas - Wave Propagation – Velocity of Sound - Subsonic and Supersonic Flows – Fundamental Equations - Discharge from a Reservoir – Stream tube Area-Velocity Relation - De Laval Nozzle – Supersonic Flow Generation – Diffusers - Dynamic Head Measurement in Compressible Flow - Pressure Coefficient.

**UNIT II: NORMAL SHOCK WAVES** **10**

Introduction – Equations of Motion for a Normal Shock Wave - The Normal Shock Relations for a Perfect Gas - Change of Stagnation or Total Pressure across the Shock- Hugoniot Equation - The Propagating Shock Wave - Reflected Shock Wave - Centered Expansion Wave - Shock Tube.

**UNIT III: OBLIQUE SHOCK AND EXPANSION WAVES** **10**

Introduction – Oblique Shock Relations - Relation between $\theta$ and $\beta$- Shock Polar – Supersonic Flow over a Wedge - Weak Oblique Shocks – Supersonic Compression - Supersonic Expansion by Turning - The Prandtl-Meyer Expansion - Simple and Non-simple Regions.

**UNIT IV: MEASUREMENTS IN COMPRESSIBLE FLOW** **10**

Introduction - Pressure Measurements – Temperature Measurements - Velocity and Direction - Density Problems - Compressible Flow Visualization - High-Speed Wind Tunnels - Instrumentation and Calibration of Wind Tunnels.

**UNIT V: INTRODUCTION TO RAREFIED AND HIGH TEMPERATURE GAS DYNAMICS** **5**

Knudsen Number - Slip Flow Transition and Free Molecule Flow - Importance of High-Temperature Flows - Nature of High-Temperature Flows.

**TOTAL: 45 HOURS**

**TEXT BOOKS:**

1. J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill Education, 6th edition, 2017.
2. Rathakrishnan. E., Gas Dynamics, Prentice Hall of India, 7th edition, 2020.

**REFERENCES:**

1. Shapiro, AH, "Dynamics & Thermodynamics of Compressible Fluid Flow", Ronald Press, 1982.
2. Houghton, EL and Caruthers, NB," Aerodynamics for Engineering Students", Butterworth- Heinemann Series, 7th Edition 2017.
3. Zucrow, M.J, and Anderson, J.D, "Elements of gas dynamics" McGraw-Hill Book Co., New York, 1989.
4. Rae, WH and Pope, A, "Low speed Wind Tunnel Testing", John Wiley Publications, 3rd edition, 1999.

| **AE45B8** | **FATIGUE AND FRACTURE MECHANICS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**OBJECTIVES**

- To learn the basic mechanisms of fatigue crack initiation and growth in metals.
- To analyse the fracture due to fatigue and analysis of unstable fracture in materials.

| **Course Outcome – Cos** | | **Cognitive Skill** |
|---|---|---|
| CO-01 | To study the basic concept of mean stress, Goodman, Gerber and Soderberg relations and stress concentrations. | U |
| CO-02 | To evaluate low cycle and high cycle fatigue, Coffin-Manson's relation and cycle counting techniques. | E |
| CO-03 | To understand the basics of crack initiation, crack growth and final fracture. | U |
| CO-04 | To study the stress analysis of cracked bodies and effect of thickness on fracture toughness. | An |
| CO-05 | To analyse the parameters affecting the critical crack-tip opening displacement. | An |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| **PO/CO** | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | L | L | S | L | S | N | L | L | N | M | L | M |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-02** | S | M | S | M | L | M | N | N | L | N | S | N | S |
| **CO-03** | L | L | M | L | S | L | N | N | L | N | L | L | M |
| **CO-04** | M | S | L | S | N | M | N | L | L | N | M | M | L |
| **CO-05** | L | L | N | S | M | L | N | L | L | N | M | M | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: FATIGUE OF STRUCTURES** **10**

S.N. curves – Endurance limit – Effect of mean stress – Goodman, Gerber and Soderberg relations and diagrams – Notches and stress concentrations – Neuber's stress concentration factors – plastic stress concentration factors – Notched S-N curves.

**UNIT II: STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR** **8**

Low cycle and high cycle fatigue – Coffin-Manson's relation – Transition life – Cyclic Strain hardening and softening – Analysis of load histories – Cycle counting techniques – Cumulative damage – Miner's theory – other theories.

**UNIT III: HYSICAL ASPECTS OF FATIGUE** **5**

Phase in fatigue life – Crack initiation – Crack growth – Final fracture – Dislocations – Fatigue fracture surfaces.

**UNIT IV: FRACTURE MECHANICS** **15**

Strength of cracked bodies – potential energy and surface energy – Griffith's theory – Irwin – Orwin extension of Griffith's theory to ductile materials – Stress analysis of cracked bodies – Effect of thickness on fracture toughness – Stress intensity factors for typical geometries.

**UNIT V: ELASTIC PLASTIC FRACTURE MECHANICS** **7**

Fracture beyond general yield. The Crack-tip opening displacement - Use of CTOD criteria - Experimental determination of CTOD - Parameters affecting the critical CTOD, Use of J integral - Limitation of J integral.

**TOTAL: 45 HOURS**

**TEXT BOOKS**


1. D.Brock, "Elementary Engineering Fracture Mechanics", Noordhoff International Publishing Co., London, 1994.
2. Anderson, "Fracture Mechanics-Fundamental and Application", T.L CRC press1998.
3. J.F.Knott, "Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London, 1983.


**REFERENCES**


1. W.Barrois and L.Ripley, "Fatigue of Aircraft Structures", Pergamon Press, Oxford, 1983.
2. C.G.Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.
3. Engineering fracture mechanics - S.A. Meguid Elsevier.
4. Fracture of Engineering Brittle Materials, Applied Science - Jayatilake, London.
5. Fracture and Fatigue Control in Structures- Rolfe and Barsom, Prentice Hall.

| AE45B9 | AVIONICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To introduce the basic concepts of navigation & communication systems of aircraft.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | To know the need for avionics in civil and military aircraft and space systems. | U |
| CO-02 | To apply the fundamentals of logic and combinational logic circuit. | A |
| CO-03 | To analyse the avionics system architecture and salient features and applications of data buses. | An |
| CO-04 | To understand the fundamentals of control and display technologies and cockpits. | R |
| CO-05 | To study avionics systems such as communication systems navigation systems and flight control systems. | U |

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | M | N | M | S | S | N | M | M | N | M | L | S |
| **CO-02** | L | M | L | M | S | M | N | S | L | N | S | M | M |
| **CO-03** | L | M | N | L | L | L | N | L | M | N | L | N | S |
| **CO-04** | M | M | L | S | S | M | N | S | L | N | M | M | M |
| **CO-05** | M | S | L | M | S | L | N | S | L | N | S | M | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION TO AVIONICS** **8**

Need for Avionics in civil and military aircraft and space systems – Integrated Avionics system – Typical avionics sub systems – Design approaches and recent advances - Application Technologies.

**UNIT II: PRINCIPLES OF DIGITAL SYSTEMS** **10**

Digital Computers – Digital number system- number systems and codes-Fundamentals of logic and combinational logic circuits –Digital arithmetic – interfacing with analogue systems - Microprocessors – Memories.

**UNIT III: DIGITAL AVIONICS ARCHITECTURE** **8**

Avionics system architecture– salient features and applications of Data buses MIL–STD 1553 B–ARINC 429–ARINC 629.

**UNIT IV: FLIGHT DECK AND COCKPITS** **9**

Control and display technologies CRT, LED, LCD, EL and plasma panel - Touch screen - Direct voice input (DVI) - Civil cockpit and military cockpit: MFDS, HUD, MFK, HOTAS

**UNIT V: AVIONICS SYSTEMS** **10**

Communication Systems - Navigation systems - Flight control systems - Radar electronic warfare - Utility Systems Reliability and maintainability - Certification.

**TOTAL: 45 HOURS**

**TEXT BOOKS**

1. Malcrno A.P. and Leach, D.P., "Digital Principles and Application", Tata McGraw-Hill, 1990.
2. Gaonkar, R.S., "Microprocessors Architecture – Programming and Application", Wiley and Sons Ltd., New Delhi, 1990.

**REFERENCES**

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989.
2. Spitzer, C.R., "Digital Avionic Systems", Prentice Hall, Englewood Cliffs, N.J., USA., 1987.
3. Brain Kendal, "Manual of Avionics", The English Book House, 3rd Edition, New Delhi, 1993.

## OPEN ELECTIVES

| SI. No. | SUBJECT CODE | SUBJECT NAME | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | OE45D1 | RESEARCH METHODOLOGY AND IPR | 2 | 0 | 0 | 2 |
| 2. | OE45D2 | BUSINESS ANALYTICS | 3 | 0 | 0 | 3 |
| 3. | OE45D3 | INDUSTRIAL SAFETY | 3 | 0 | 0 | 3 |
| 4. | OE45D4 | OPERATIONS RESEARCH | 3 | 0 | 0 | 3 |
| 5. | OE45D5 | COMPOSITE MATERIALS | 3 | 0 | 0 | 3 |
| 6. | OE45D6 | WASTE TO ENERGY | 3 | 0 | 0 | 3 |

| OE45D1 | RESEARCH METHODOLOGY & IPR | L | T | P | C |
|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 2 |

**OBJECTIVE**

To learn the importance of research methodology and intellectual property rights among students in general.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | Illustrate research problem formulation. | U |
| CO-02 | Analyze research related information and research ethics. | An |
| CO-03 | Correlate the results of any research article with other published results and write a review article in the field of engineering. | E |

| | | |
|---|---|---|
| CO-04 | Explain why intellectual property rights (IPR) will play such a significant role in the development of people and nations, and briefly discuss the necessity to spread awareness of IPR among students in general and engineers in particular. | U |
| CO-05 | Discuss how IPR protection encourages innovators to conduct additional research and invest in R & D, which results in the development of new and improved products, which in turn leads to economic growth and societal benefits. | An |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome.**

| **PO/CO** | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | L | L | N | M | S | M | S | N | M | S | S | S | N |
| **CO-02** | L | M | L | S | S | S | S | N | M | S | M | M | N |
| **CO-03** | L | L | M | L | S | S | S | N | S | S | S | S | L |
| **CO-04** | N | M | S | M | S | M | S | L | M | S | S | M | L |
| **CO-05** | L | L | S | L | S | M | S | L | M | S | S | M | L |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: RESEARCH METHODOLOGY** **6**

Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

**UNIT II: LITERATURE SURVEY AND ETHICS** **6**

Effective literature studies approaches - analysis Plagiarism - Research ethics.

**UNIT III: TECHNICAL WRITING** **6**

Effective technical writing - how to write a manuscript/ responses to reviewers comments - preparation of research article/ research report - Writing a Research Proposal - presentation and assessment by a review committee.

**UNIT IV: INTELLECTUAL PROPERTY RIGHTS** **6**

Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright - Process of Patenting and Development: technological research, innovation, patenting & development - Procedure for grants of patents - Patenting under PCT.

**UNIT V: PATENT RIGTS AND NEW DEVELOPMENTS IN IPR** **6**

Scope of Patent Rights - Licensing and transfer of technology - Patent information and databases - Geographical Indications - New Developments in IPR: Administration of Patent System - New developments in IPR - IPR of Biological Systems - Computer Software etc. - Traditional knowledge.

**TOTAL: 30 HOURS**

**TEXT BOOKS:**


1. C.R.Kothari, "Research Methodology", 3rd Edition, New Age International, 2017.
2. Ranjit Kumar, "Research Methodology – A Step by Step for Beginner's", 2nd Edition, Pearson, Education, 2016.

3. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
4. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
5. Kompal Bansal & Parshit Bansal, "Fundamentals of IPR for Beginner's", 1st Edition, BS Publications, 2016.

**REFERENCES:**

1. Kothari, C. R. Research Methodology - Methods and Techniques, New Age International publishers, New Delhi, 2004.
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974. 7. Asimov , "Introduction to Design", Prentice Hall, 1962.

**WEB RESOURCE**:

1. https://nptel.ac.in/courses/106/105/106105077/

| OE45D2 | BUSINESS ANALYTICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To learn the principles of organizational structures for effective business analytics.

| Course Outcome – COs | | Cognitive Skill |
|---|---|---|
| CO-01 | Analyze business data using statistical tools. | An |
| CO-02 | Apply trend analysis and regression to make informed decisions. | A |
| CO-03 | Design organizational structures for effective business analytics | S |
| CO-04 | Utilize forecasting techniques for prediction and decision-making. | An |
| CO-05 | Employ decision analysis methods and stay updated on recent trends in business intelligence and data storytelling. | E |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome.**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | L | N | L | M | M | M | N | M | S | S | S | M |
| **CO-02** | N | N | L | S | S | S | S | N | M | M | M | M | M |
| **CO-03** | N | L | M | L | S | S | S | N | S | S | S | S | N |
| **CO-04** | N | S | N | M | M | M | S | L | S | S | S | M | N |
| **CO-05** | L | S | N | L | N | M | S | L | M | S | S | M | L |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I** **9**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.
Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

**UNIT II** **9**

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.
Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

**UNIT III** **9**

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

**UNIT IV** **9**

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.
Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

**UNIT V** **9**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making, Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

**TOTAL: 45 HOURS**

**REFERENCES**


1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.
2. Business Analytics by James Evans, persons Education.


| OE45D3 | INDUSTRIAL SAFETY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study the principles of fault tracing techniques to diagnose equipment problems.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | Identify and mitigate industrial safety hazards effectively. | U |

| | | |
|---|---|---|
| CO-02 | Apply maintenance engineering principles to optimize equipment performance. | An |
| CO-03 | Implement strategies for wear reduction and corrosion prevention. | E |
| CO-04 | Utilize fault tracing techniques to diagnose equipment problems efficiently. | R |
| CO-05 | Develop and execute periodic and preventive maintenance programs for machinery and equipment. | E |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome.**

| **PO /CO** | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | L | L | S | L | S | M | N | S | S | S | S | S | L |
| **CO-02** | L | N | M | S | S | S | N | S | S | M | M | M | M |
| **CO-03** | L | L | M | L | S | S | N | S | S | S | S | S | L |
| **CO-04** | N | S | M | M | M | M | N | S | S | S | N | M | L |
| **CO-05** | L | S | S | L | S | M | N | S | L | S | S | M | L |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I** **9**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**UNIT II** **9**

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**UNIT III** **9**

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**UNIT IV** **9**

Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**UNIT V** **9**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

**TOTAL: 45 HOURS**

**REFERENCES**


1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.


| OE45D4 | OPERATIONS RESEARCH | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study the importance of ooptimization techniques, model formulation, scheduling and sequencing and non linear programming problem.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | Formulate and solve optimization problems using simplex method, sensitivity analysis, and parametric programming. | S |
| CO-02 | Apply linear programming to model real-world scenarios, understand duality theory, and analyze sensitivity. | A |
| CO-03 | Solve nonlinear programming problems with Kuhn-Tucker conditions. | E |
| CO-04 | Develop scheduling and sequencing models for resource utilization and inventory control. | S |
| CO-05 | Apply competitive modeling, dynamic programming, and game theory to optimize decision-making in various scenarios. | A |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome.**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | S | S | N | L | M | M | N | S | S | L | S | S | N |
| **CO-02** | S | S | L | S | S | S | N | S | S | N | M | M | L |
| **CO-03** | M | S | L | L | S | S | N | S | S | N | S | S | M |
| **CO-04** | M | S | M | M | M | M | N | S | S | L | N | M | M |
| **CO-05** | M | S | N | L | S | M | N | S | L | S | L | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I** **9**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

**UNIT II** **9**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

**UNIT III** **9**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

**UNIT IV** **9**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

**UNIT V** **9**

Competitive Models, Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

**TOTAL: 45 HOURS**

**REFERENCES**


1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010


| OE45D5 | COMPOSITE MATERIALS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To impart the knowledge of different reinforcements used in composites, classifications, preparation methods, properties, characteristics, and advantages of composite materials, along with their applications in various industries.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | Understand the classification, characteristics, and advantages of composite materials, along with their applications in various industries. | U |
| CO-02 | Demonstrate knowledge of different reinforcements used in composites and their preparation methods, properties, and applications. | An |
| CO-03 | Gain proficiency in manufacturing metal matrix composites, ceramic matrix composites, and polymer matrix composites, including | R |

| | | |
|---|---|---|
| | understanding the processes involved and their resulting properties. | |
| CO-04 | Analyze the mechanical behavior and strength of composite materials, including failure criteria and design considerations for laminated structures. | An |
| CO-05 | Apply learned concepts to solve real-world problems related to the design, manufacturing, and application of composite materials in engineering projects. | E |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | M | M | N | L | M | M | N | S | S | N | S | S | S |
| **CO-02** | M | M | S | M | S | S | N | S | S | N | M | M | S |
| **CO-03** | L | M | S | L | S | S | N | S | S | N | S | S | S |
| **CO-04** | L | M | M | M | M | M | N | S | S | N | N | M | S |
| **CO-05** | L | M | N | L | S | M | N | S | L | N | L | L | S |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION 9**

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT II: REINFORCEMENTS 9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

**UNIT III: MANUFACTURING OF METAL MATRIX COMPOSITES 9**

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

**UNIT IV: MANUFACTURING OF POLYMER MATRIX COMPOSITES 9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

**UNIT V: STRENGTH 9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TOTAL: 45 HOURS**

**TEXT BOOKS**

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

**REFERENCES**

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.
3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

| OE45D6 | WASTE TO ENERGY | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**OBJECTIVE**

To study about biomass pyrolysis and gasification techniques and classify waste types for energy generation, biomass conversion processes and biogas properties, plant technology, and applications.

| Course Outcome – Cos | | Cognitive Skill |
|---|---|---|
| CO-01 | Identify and classify waste types for energy generation. | R |
| CO-02 | Apply biomass pyrolysis and gasification techniques. | A |
| CO-03 | Understand biomass combustion principles and technologies. | U |
| CO-04 | Analyze biogas properties, plant technology, and applications. | An |
| CO-05 | Evaluate biomass conversion processes and related energy programs. | E |

R- Remember, U-Understand, A-Apply, An-Analyse, E-Evaluate, S- Synthesis

**Mapping of Course Outcome with Programme Outcome**

| PO/CO | PO-A | PO-B | PO-C | PO-D | PO-E | PO-F | PO-G | PO-H | PO-I | PO-J | PO-K | PO-L | PO-M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO-01** | L | L | S | L | S | M | N | S | M | M | M | M | M |
| **CO-02** | L | L | S | M | S | S | N | S | S | N | M | M | M |
| **CO-03** | L | L | S | L | S | S | N | S | S | N | M | L | L |
| **CO-04** | M | L | S | M | S | M | N | S | S | N | N | M | S |
| **CO-05** | M | N | S | L | S | M | N | S | L | N | L | L | M |

S- Strong, M- Medium, L-Low, N- Not Relevant

**UNIT I: INTRODUCTION TO ENERGY FROM WASTE** **9**

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

**UNIT II: BIOMASS PYROLYSIS** **9**

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**UNIT III: BIOMASS GASIFICATION** **9**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**UNIT IV: BIOMASS COMBUSTION** **9**

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**UNIT V: BIOGAS** **9**

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

**TOTAL: 45 HOURS**

**REFERENCES**


1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.