# MVJ College of Engineering, Whitefield, Bangalore

*An Autonomous Institution, Affiliated to VTU, Belagavi*

Scheme of Teaching and Examination 2022

Effective from the academic year 2022-23

**Department of Aeronautical Engineering-PG Program**

**I SEMESTER M.Tech AE**

| S. No | Course | | Course Title | Teaching Department | Teaching hours/week | | | Examination | | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory | Practical / Seminar | Tutorial / Skill Development Activity | Self-Study Component | Duration in Hours | CIE Marks | SEE Marks | Total marks | |
| | Type | Code | | | L | T | P | S | | | | | |
| 1 | BSC | MVJ22MAE11 | Applied Mathematics | Mathematics | 3 | 0 | 0 | 0 | 3 | 50 | 50 | 100 | 3 |
| 2 | IPCC | MVJ22MAE12 | Aerospace Propulsion (+ Propulsion Lab) | AE | 3 | 2 | 0 | 0 | 3 | 50 | 50 | 100 | 4 |
| 3 | PCC | MVJ22MAE13 | Aerodynamics | AE | 3 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 4 |
| 4 | PCC | MVJ22MAE14 | Introduction to Aerospace Vehicles and Systems | AE | 2 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 3 |
| 5 | PCC | MVJ22MAE15 | Finite Element Methods | AE | 2 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 3 |
| 6 | MCC | MVJ22IPR16 | Research Methodology and IPR | AE | 3 | 0 | 0 | 0 | 3 | 50 | 50 | 100 | 3 |
| 7 | PCCL | MVJ22MAEL17 | Aerodynamic Lab | AE | 1 | 2 | 0 | 0 | 3 | 50 | 50 | 100 | 2 |
| 8 | AUD/AEC | MVJ22MAE18 | (online) | AE | Classes and evaluation procedures are as per the policy of the online course providers | | | | | | | | PP |
| **Total** | | | | | **17** | **4** | **6** | **-** | **-** | **350** | **350** | **700** | **22** |

Note: BSC-Basic Science Courses, PCC: Professional core. IPCC-Integrated Professional Core Courses, MCC- Mandatory Credit Course, AUD/AEC –Audit Course / Ability Enhancement Course(A pass in AUD/AEC is mandatory for the award of the degree), PCCL-Professional Core Course lab, **L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities**(Hours are for Interaction between faculty and students). PP/NP-Passed / Not Passed (Only for non-Credit Course)

| Semester: I | | |
|---|---|---|
| **APPLIED MATHEMATICS** | | |
| **Course Code: MVJ22MAE11** | | **CIE Marks: 50** |
| **Credits: L: T:P:S: 3:0:0:0** | | **SEE Marks: 100** |
| **Hours: 30L+20T** | | **SEE Duration: 3 Hrs.** |
| **Course Learning Objectives: The students will be able to** | | |
| 1 | Acquire Knowledge of Numerical Differentiation and Integration | |
| 2 | Understand Tensors and Algebra of Tensors | |
| 3 | Gain Knowledge of Optimisation Techniques | |
| 4 | Understand the Application of Variational Methods | |

| **UNIT-I** | |
|---|---|
| **Numerical Differentiation & Integration**<br><br>Numerical Differentiation – Formulae for derivatives, differentiation via interpolation, Richardson`s extrapolation.<br><br>Numerical Integration Composite numerical integration, Romberg integration, Inherent errors in numerical integrations; Newton-Cotes quadrature formula; Euler-Maclaurin formula; Adaptive quadrature method, Gaussian quadrature, Multiple integrals.<br><br>**Applications:** Analysis techniques in Aeronautical field<br>**Self study topic:** Method for undetermined coefficients<br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | **10 Hrs** |
| **UNIT-II** | |
| **Multilinear Algebra:**<br><br>Review of linear algebra-vector spaces, linear transformation, Eigen bases. Multilinearity. Tensor as a generalized concept of a vector in a Euclidean space. Tensor ranks, properties of matrix ranks, properties of multilinear rank, algebraic computational complexity. Contravariant and covariant vectors and mixed tensors; symmetric and skew- symmetric tensors. Addition and scalar multiplication. Outer and Inner products of tensors; Quotient law.<br><br>**Applications:** Flow simulation, Structural analysis, Stability & Control of flight vehicles<br>**Self study topic:** Application-Inertia tensor, stress tensor, contravariance of stress tensor.<br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | **10 Hrs** |
| **UNIT-III** | |
| **Optimisation Techniques:**<br><br>Unconstrained optimisation- Category of optimisation methods. Optimality condition (univariate/multi-variate). Single variable optimisation, maxima/minima of a function, Unimodel-Fibonacci method. Polynomial based method. Multivariable optimisation. Steepest decent method, conjugate gradient method. Optimisation algorithm (analytical, and numerical). Constrained optimisation-Lagrange method, Augmented Lagrange technique.<br><br>**Applications:** Aerodynamic optimisation, Structural optimisation, Multi-disciplinary optimisation | **10 Hrs** |

| | |
|---|---|
| **Self study topics:** Quadratic programming<br><br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | |
| **UNIT-IV** | |
| **Variational Methods-I:**<br><br>Euler Lagrange necessary condition for an extremum and constraints. Euler Lagrange multiplier theorem for many constraints, and proof of the theorem. Application of Euler-Lagrange multiplier theorem in calculus of variations. Problems with fixed end points & variable end points.<br><br>**Application:** Development and Solution of Differential equations<br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | **10 Hrs** |
| **UNIT-V** | |
| **Variational Methods-II:**<br><br>Use of second variation in Extremum problems, necessary and sufficient conditions for extremum. Du Bois-Reymond`s theorem. Function of several variables, Dirichlet` principle.<br><br>**Application:** Development and Solution of Differential equations.<br>**Self study topics:** Eigenvalue problem formulation as a variational problem.<br><br>**Video Link**:<br>1. http://nptel.ac.in/courses.php?disciplineID=111 | **10 Hrs** |

| **Course Outcomes: After completing the course, the students will be able to** | |
|---|---|
| CO1 | Analyse flow field and aero-structures, aero systems related problems. |
| CO2 | Perform Flow simulation, Structural analysis, Stability & Control of flight vehicles |
| CO3 | Evaluate Multi-disciplinary optimal solutions |
| CO4 | Develop and solve object orientated differential equations |
| CO5 | Develop and solve object orientated differential equations for several variables. |

| **Reference Books** | |
|---|---|
| **1.** | Ray M Bowen & C._C.Wang, `Introduction to Vectors and Tensors, Vol1: Linear & Multilinear Algebra,1976. |
| **2.** | Kevin W. Cassel,` Variational Methods with Applications in Science & Engineering, Cambridge University Press,2013. |
| **3.** | D James Benton, `Numerical Calculus: Differentiation & Integration`,2018, ISBN-13:978-1980680901 |
| **4.** | Jorge Nocedal & Stephen J. Wright, 'Numerical Optimization`, Springer,2006 |

**Continuous Internal Evaluation (CIE):**

**Theory for 50 Marks**

CIE is executed by way of quizzes (Q), tests (T) and assignments. A minimum of three quizzes are conducted along with tests. Test portion is evaluated for 50 marks and quiz is evaluated for 10 marks. Faculty may adopt innovative methods for conducting quizzes effectively. The number of quizzes may be more than three (conduct additional quizzes and take best three). The three tests are conducted for 50 marks each and the average of all the tests are calculated for 50. The marks for the assignments are 20 (2 assignments for 10 marks each). The marks obtained in test, quiz and assignment are added to get marks out of 100 and report CIE for 50 marks.

**Semester End Examination (SEE):**

**Total marks: 50+50=100**

**SEE** for 50 marks is executed by means of an examination. The Question paper for each course contains two parts, Part – A and Part – B. Part – A consists of objective type questions for 20 marks covering the entire syllabus. Part – B Students have to answer five questions, one from each unit for 16 marks adding up to 80 marks. Each main question may have a maximum of three sub divisions. Each unit will have internal choice in which both questions cover entire unit having same complexity in terms of COs and Bloom's taxonomy level.

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| CO3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CO5 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

High-3, Medium-2, Low-1

| Course Title | AEROSPACE PROPULSION+(PROPULSION LAB) | Semester | I |
|---|---|---|---|
| Course Code | MVJ22MAE12 | CIE | 50 |
| Total No. of Contact Hours | 50 L:P:T:S 3:2:0:0 | SEE | 50 |
| No. of Contact Hours/week | 5 | Total | 100 |
| Credits | 4 | Exam. Duration | 3 Hrs. |

Course objective is to:

- Understand and apply the basic thermodynamic principles in aircraft propulsion.
- Understand and solve the problems on turboprop, turbojet and turbofan engines.
- Acquire knowledge on chemical rocket propulsion
- Describe the working of solid rocket motors
- Understand the liquid and hybrid rocket propulsion

| Module 1 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Introduction to propulsion devices

Introduction to various air breathing and non-air breathing engines: Turbojet, Turboprop, Turbofan, Ramjet, Scramjet, rockets - Conservation equations and derivation of the thrust equation for air breathing and non-air breathing engines - Efficiencies of air breathing and non-air breathing engines.

Laboratory Sessions/ Experimental learning:

1. Learn NASA's EngineSimApplet Version 1.8a (latest edition) by using Beginner's Guide to Propulsionhttps://www.grc.nasa.gov/WWW/K-12/airplane/ngnsim.html
2. Calculate and draw the performance curves using EngineSimApplet Version 1.8a

Applications: Performance and efficiency calculation in airplane enginesVideo link / Additional online information (related to module if any):

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsionsystems-spring-2012/lecture-notes/MIT16_50S12_lec17.pdf
2. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsionsystems-spring-2012/lecture-notes/MIT16_50S12_lec18.pdf

| Module 2 | L1,L2,L3, | 08 Hrs. |
|---|---|---|

Cycle analysis

Cycle analysis of Ramjet, Turbojet, Turbofan, Turboprop, Turbo-shaft engines - Engine health monitoring systems.

Fuel cells: Working and construction of fuel cells, Various types of fuel cells, Application of fuel

cells in aero industry.

**Maintenance, overhaul and testing**: Overhaul, Maintenance techniques, engine performance monitoring, The test cell, Performance testing, Ground operating procedures, Starting a gas turbine engines, Engine operation and checks, Engine ratings Laboratory Sessions/ Experimental learning:

1. Learn NASA's Range Games Version 1.3 (latest edition) by using Beginner's Guide to Propulsionhttps://www.grc.nasa.gov/WWW/K-12/airplane/ngnsimr.html
2. Calculate and understand the aircraft motion and performance using Range Games Version 1.3

**Applications**: Performance and efficiency calculation in airplane engines, Aircraft engine maintenance overhaul and testing industry

**Video link / Additional online information (related to module if any)**:

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsionsystems-spring-2012/lecture-notes/MIT16_50S12_lec16.pdf
2. https://nptel.ac.in/courses/101106033/

| Module 3 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Solid rocket motors

**Solid propellants** :Various solid propellants, The burring rate, Propellant grain and grain configuration, Propellant grain stress and strain, Propellant Ingredients, Three dimensional grains, Burning rate augmentation

**Solid Rocket Components and Motor Design**: Motor case, Nozzle, Rocket motor design approach.

**Combustion of Solid Propellants** :Physical and chemical processes, Ignition process, Ignitors, Extinction or Thrust termination, Combustion instability

**Laboratory Sessions/ Experimental learning**:

1. Make Sugar rocket by using potassium nitrate (small size)
2. Find the specific impulse of the sugar rocket

**Applications**: Rocket Manufacturing industries

**Video link / Additional online information (related to module if any)**:

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsionsystems-spring-2012/lecture-notes/MIT16_50S12_lec9.pdf

https://nptel.ac.in/courses/101106033/

| Module 4 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Liquid Propellant Rocket Engine

**Liquid propellants**: Propellant Properties, Liquid Oxidizers, Liquid Fuels, Liquid Monopropellants, Gelled Propellants, Gaseous Propellants, Safety and Environmental Concerns,

**Liquid Rocket Components and Engine Design**: Combustion Chamber, propellant tank, Nozzles, Propellant Feed Systems, Injectors, Tank Pressurization, Flow and Pressure Balance, Rocket Engines for Maneuvering, Orbit Adjustments or Attitude Control, Valves and Pipe Lines, Engine Support Structure.

**Combustion of Liquid Propellants**: Combustion Process, Analysis and Simulation, Combustion Instability, cooling of liquid engines.

**Laboratory Sessions/ Experimental learning**:

1.Case study on Indian cryogenic engines.

**Applications**: Aerospace industry

**Video link / Additional online information (related to module if any)**:

1. https://nptel.ac.in/courses/101106033/
2. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/lecture-notes/lecture_19.pdf

| Module 5 | L1,L2 | 08 Hrs. |
|---|---|---|

**Hybrid propellant rocket**: Applications and Propellants, Performance Analysis and Grain Configuration, Combustion Instability

**Thrust Vector Control** :TVC Mechanisms with a Single Nozzle , TVC with Multiple Thrust Chambers or Nozzles

**Selection of Rocket Propulsion Systems**: Selection Process, Criteria for Selection

**Electric Propulsion**: Ideal Flight Performance, Electro thermal Thrusters, Non-Thermal ElectricThrusters, Optimum Flight Performance, Mission Applications, Electric Space-Power Supplies and Power-Conditioning.

**Rocket Testing**: **Rocket Testing**: Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Description of atypical space launch vehicle launch procedure.

**Laboratory Sessions/ Experimental learning**:

1. Develop a model ion propulsion laboratory kit
2. Calculate the specific impulse of a hybrid rocket using thrust stand

**Applications**: Aerospace industry

**Video link / Additional online information (related to module if any)**:

1. https://nptel.ac.in/courses/101106033/
2. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/lecture-notes/lecture_17_18.pdf

Course outcomes:

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

| | |
|---|---|
| CO1 | Explain the construction and working principle of various propulsion devices |
| CO2 | Enumerate and suggest solution for gas turbine engine related problems |
| CO3 | Solve chemical rocket combustion related problems |
| CO4 | Estimate solid rocket burn rate and related parameters |
| CO5 | Determine the requirements of hybrid rockets and space missions |

Reference Books:


| | |
|---|---|
| 1. | Kroes, Michael J. Aircraft power plants. McGraw-Hill/Glencoe, 1990. |
| 2. | Treager, Irwin E., and Irwin E. Treagan. Aircraft gas turbine engine technology. Vol. 1995. New York, USA: McGraw-Hill, 1979. |
| 3. | Sutton, George P., and Oscar Biblarz. "Rocket Propulsion Elements JOHN WILEY & SONS." Inc., New York, 2001. |
| 4. | E. Irwin Treager, "Aircraft Gas Turbine Engine Technology", 3rd Edition, 1995 'ISBN-02018281. |


CO, PO Mapping

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | AIRCRAFT PROPULSION LABORATORY | Semester | I |
|---|---|---|---|
| Course Code | MVJ22MAE12 | CIE | 50 |
| Total No. of Contact Hours | | SEE | 50 |
| No. of Contact Hours/week | | Total | 100 |
| Credits | | Exam. Duration | 3 Hours |

Course objective is to:

1. Familiarization with various propulsion experimental facilities
2. Familiarize with different propulsion experiments and measurement techniques
3. Conduct the test, acquire the data and analyse and document

| Sl No | Experiment Name | RBT Level | Hours |
|---|---|---|---|
| 1 | Cascade testing of a model of turbine blade row and study of wake survey. | L1,L2,L3 | 03 |
| 2 | Estimation of propeller performance | L1,L2,L3 | 03 |
| | | | |
| 4 | Forced Convective heat transfer on a flat surface | L1,L2,L3 | 03 |
| 5 | Measurement of Burning Velocity of a Premixed Flame | L1,L2,L3 | 03 |
| 6 | Investigation of relationship between flame speed and air-fuel ratio for a slow burning gaseous fuel. | L1,L2,L3 | 03 |
| 7 | Construction of flame stability diagram through flame lift up and flame fall back | L1,L2,L3 | 03 |
| 8 | Determination of heat of combustion of aviation fuels | L1,L2,L3 | 03 |
| | | | |
| 10 | Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit | L1,L2,L3 | 03 |
| 11 | Effect of inlet flow distortion on Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit . | L1,L2,L3 | 03 |
| 12 | Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through contra rotating axial flow fan unit | L1,L2,L3 | 03 |
| 13 | Effect of inlet flow distortion on Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through contra rotating axial flow fan unit. | L1,L2,L3 | 03 |

| | | | |
|---|---|---|---|
| | | | |
| | | | |
| Course outcomes: | | | |
| CO1 | Understand the working procedure of piston engine, Gas Turbine Engine | | |
| CO2 | Evaluate the calorific value of the fuel provided and heat transfer rate of the provided metal plate. | | |
| CO3 | Experiment the flow over nozzle and free jet & wall jet to determine the flow properties | | |
| | Estimate the pressure distribution over airfoil and thrust generated. | | |

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| CO2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| CO3 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |

High-3, Medium-2, Low-1

| Course Title | AERODYNAMICS | Semester | I |
|---|---|---|---|
| Course Code | MVJ22MAE13 | CIE | 50 |
| Total No. of Contact Hours | 50 L:T:P:S 3:0:2:0 | SEE | 50 |
| No. of Contact Hours/week | 5 | Total | 100 |
| Credits | 4 | Exam. Duration | 3 Hrs. |

Course objective is to:

- Gain knowledge of incompressible flows over aerofoil
- Understand aerofoil and wing aerodynamic characteristics and theory of lift generation
- Learn about high speed flows over aerofoils
- Acquire knowledge of potential flow equations & its Applications
- Acquire knowledge of Unsteady Flows

| Module 1 | L1,L2,L3 | 10 Hrs. |
|---|---|---|

Basics of Aerodynamics: Properties of fluids, Characteristics of Atmosphere, Type of fluid flows, Generation of Lift, Drag and Moment, Incompressible flows over airfoils, calculation of lift and drag from measured pressure distribution, Streamlined and bluff-body, Reynolds number and Mach number, Conservation law of mass and momentum, Euler and Bernoulli's equations, pitot-tube measurement of airspeed. Pressure coefficient. Streamlines, path lines and streak lines. Angular velocity, vorticity, circulation Stream function, velocity potential and their relationship. Governing equation for irrotational and incompressible fluid flow.

**Laboratory Sessions/ Experimental learning:**

Flow over an aerofoil: Pressure distribution and Force at various angles of attack

**Applications**

Applicable in standardAirplane Design

**Video link / Additional online information (related to module if any):** https://nptel.ac.in/courses/101105059/

| Module 2 | L1,L2,L3, | 10 Hrs. |
|---|---|---|

Aerodynamics of Airfoils and Wings: Airfoil nomenclature and classification, Low speed aerodynamic characteristics of symmetric and cambered airfoils, Centre of pressure, aerodynamic centre and aerodynamic moment, Concept of point vortex, line vortex and vortex sheet, Kutta condition, Kelvins circulation theorem and starting vortex, Classical thin airfoil theory and symmetric airfoil. Finite wing nomenclature. Incompressible flow over wing, vortex filament, bound vortex, horse shoe vortex, downwash, induce angle of attack and drag. Type of

drag. Biot-Savart law and Helmholtzs vortex theorem. Prandtls lifting line theory and limitations. Elliptic lift distributions, expression for induced angle of attack and induce drag. Two dimensional and three dimensional wings lift curve slope and effect of aspect ratio. High lift devices.

**Laboratory Sessions/ Experimental learning:**

Flow over the various wing configurations **Applications**

Applicable in standardAirplane Design

**Video link / Additional online information (related to module if any):**
https://nptel.ac.in/courses/101/104/101104073/

| **Module 3** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

High speed Aerodynamics: Fundamentals of thermodynamic concepts, conservation of energy. Speed of sound, Mach wave and Mach angle. Normal shock wave, Oblique shock wave, Expansion fan, Prandtl-Meyer expansion. Family of shocks. Flow through convergent divergent nozzle. Hodograph and pressure turning angle. Rankine- Hugoniot relation.

**Laboratory Sessions/ Experimental learning:**

Flow Visualisation at high speeds

**Applications**

Applicable in standardAirplane Design

**Video link / Additional online information (related to module if any):**
https://nptel.ac.in/courses/101105023/

| **Module 4** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

Compressible flow over airfoil: Full velocity potential equation. Small perturbationtheory. Linearized velocity potential equation and boundary conditions. Pressure coefficient for small perturbation. Prandtl- Glauret compressibility correction. Critical Mach number, Drag Divergence Mach Number, Sound barrier. Transonic area rule, supercritical airfoil, swept wing and delta wing.

**Laboratory Sessions/ Experimental learning:**

Estimation Compressible flow pressure distribution and thereby estimate Drag Divergence Mach number for the given aerofoil

**Applications**

Applicable in standardAirplane Design

**Video link / Additional online information (related to module if any):**
https://nptel.ac.in/courses/101105023/

| **Module 5** | **L1,L2** | 10 Hrs. |
|---|---|---|

Unsteady Aerodynamics-Aerofoils undergoing small amplitude heave & pitch motion. Effect of harmonically oscillating aerofoils on resulting forces & moments. Unsteady analysis of separated aerodynamic flow. Unsteady loads acting of aircraft.Transition to turbulent flow in aerodynamics.

**Applications**

Applicable in unsteady flow analysis

**Video link / Additional online information (related to module if any):**

https://www.youtube.com/watch?v=-pcED7Qy8Io&t=1s

https://www.youtube.com/watch?v=vj_k6VD52nA

Course outcomes:

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

| | |
|---|---|
| CO1 | Solve aerodynamic problems related to pressure distribution |
| CO2 | Estimate the lift coefficient of an arbitrary wing configuration |
| CO3 | Evaluate compressible one dimensional flows through varying area ducts |
| CO4 | Analyse problems related to normal and oblique shock wave |
| CO5 | Analyse unsteady flows |

Reference Books:


| | |
|---|---|
| 1. | Anderson J.D., Introduction to Flight, McGraw Hill, 1987 |
| 2. | McCormick B.W., Aerodynamics, Aeronautics and Flight Mechanics, John Wiley & Sons New York, 1979. |
| 3. | Anderson J.D., Foundation of Aerodynamics, McGraw Hill Book Co, New York, 1985. |
| 4. | John D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill publication |


CO, PO Mapping

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 3 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 3 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO5 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS | Semester | I |
|---|---|---|---|
| Course Code | MVJ22MAE14 | CIE | 50 |
| Total No. of Contact Hours | 40 L:T:P:S 2:0:2:0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

Course objective is to:

1. Understand configurational features of fixed wing and rotary wing aircraft
2. Learn various aircraft systems and flight testing concepts
3. Gain knowledge of standards and specifications used in aircraft and system designs
4. Understand spacecraft launch vehicles

| Module 1 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

General introduction to aeronautics: Fixed wing & Rotary wing aircraft: Light aircraft, Fighter aircraft, Passenger aircraft, and Cargo aircraft; Light helicopter, large passenger and cargo helicopters Exploded views of various types of aircraft, identification of various structural parts and their functions and materials used.

Aircraft Systems: System design and development processes; Mechanical systems: Components and functions of Hydraulics & Landing Gear systems

Laboratory Sessions/ Experimental learning: NA

Applications: Cargo, military uses, construction, firefighting, search and rescue, tourism Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=vp9XhvezpXI

| Module 2 | L1,L2,L3, | 08 Hrs. |
|---|---|---|

Aircraft Electrical Systems: Generation, distribution and typical aircraft electrical systems and recent trends; Avionic systems: Flight control systems; Navigation system, Communication and radar systems their components and functions; Emergency systems and advanced systems.

Satellites & orbital dynamics: Satellite missions, Different types of satellites and their applications, Spacecraft configurations

Laboratory Sessions/ Experimental learning: NA

Applications: Communications Satellite, Remote Sensing Satellite, Navigation Satellite, LEO, MEO, HEO, GPS, GEOs, Drone Satellite, Ground Satellite, Polar Satellite

| | | |
|---|---|---|
| Video link / Additional online information (related to module if any):<br>https://www.youtube.com/watch?v=d5sXmNplQHw | | |
| **Module 3** | L1,L2,L3 | 08 Hrs. |
| Spacecraft Launch Vehicles: Rocket propulsion principles and types andpropellants; Sounding Rockets, Staging of rockets; major subsystems of launch vehicles and their functions; Different types of satellite launch vehicles, General description about Launch Vehicles of Indian origin.<br>Laboratory Sessions/ Experimental learning: NA<br>Applications: weaponry, ejection seats, launch vehicles for artificial satellites, human spaceflight, and space exploration<br>Video link / Additional online information (related to module if any):<br>https://www.youtube.com/watch?v=lbuCMYy7AeIhttps://www.youtube.com/watch?v=JyaYF9tpEQw | | |
| **Module 4** | L1,L2,L3 | 08 Hrs. |
| Standards & Specifications and Testing & Certification Aspects: Introduction to aircraft international and standards specifications for Military and Civil aircraft, Company standards; Airworthiness certification aspects aircraft; Ground testing and qualification testing.<br>Flight testing: Purpose and scope, Test plans and procedures; flight test instrumentation; general flying and handling characteristics of aircraft; Preparation, and conduct of tests, fault reporting.<br>Laboratory Sessions/ Experimental learning: NA<br>Applications: The test plan separates the application of the loads and environments as ... groundhandling loads, aerodynamic loads (static and transient), internal pressures. Video link / Additional online information (related to module if any):<br>https://www.youtube.com/watch?v=t4vAV-hXgMw | | |
| **Module 5** | L1,L2 | 08 Hrs. |
| Introduction to aerospace industries and institutions and their roles: Aircraft design and production industries; Components and systems manufactures, Service industries, Research and Development organizations and Academic institutions.<br>Introduction to Airport Engineering: Development of air transportation,<br>ICAO, IAAI,AAI, Aircraft characteristics which affect airport planning; Airport planning: Airport Master Plan, Regional Plan, Site selection; Terminal area and airport layout, Visual aids and ATC<br>Laboratory Sessions/ Experimental learning: NA<br>Applications: The planning, design, construction, and operation and maintenance of facilities providing for the landing and takeoff, loading and unloading, servicing, maintenance, and storage of aircraft<br>Video link / Additional online information (related to module if any): | | |

| |
|---|
| https://www.youtube.com/watch?v=NQ-Hul5FgDYhttps://www.youtube.com/watch?v=E9fbEW9rnc0 |

| Course outcomes: | |
|---|---|
| Upon completion of the course, students will be able to: | |
| CO1 | Apply the knowledge to aircraft system layouts |
| CO2 | Analyse standards and specifications for design of aircraft. |
| CO3 | Apply the knowledge to Spacecraft Launch Vehicles and their functions. |
| CO4 | Draw test plan and specify flight test instrumentation for flight test programs |
| CO5 | Apply the knowledge to Airport planning and site selection. |

| Reference Books: | |
|---|---|
| 1. | ChennaKeshu S and Ganapathy K K, Aircraft Production Technology and Management, Interline Publishing, Bangalore 1993. |
| 2. | Ian Moir and Allan Seabridge, Aircraft Systems, mechanical, electrical and avionics subsystems integration, Professional Engineering Publishing Limited, UK, 2001 |
| 3. | Ralph D Kimberlin, Flight Testing of Fixed wing Aircraft, AIAA Education Series, 2003 |
| 4. | J. Gordon Leishman, Principles of Helicopter Aerodynamics, Cambridge Aerospace series,2000. |

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO2 | 3 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO3 | 3 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO4 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO5 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 3 | 1 |

High,3, Medium,2, Low,1

| Course Title | FINITE ELEMENT METHODS | Semester | I |
|---|---|---|---|
| Course Code | **MVJ22MAE15** | CIE | 50 |
| Total No. of Contact Hours | 40 L:T:P:S 2:0:2:0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**Course objectives:** This course will enable students to

1. Understand the fundamental theory of the FEA
2. Develop the ability to generate the governing FE equations for systems governed by partial differential equations
3. Use the basic finite elements for structural applications like truss, beam, and frame
4. Understand the application and use of the FE method for heat transfer problems

| Module 1 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

**Module -1**

**Introduction to Finite Element Method, One-Dimensional Elements-Analysis of Bars:**
Engineering Analysis, History, Advantages, Classification, Basic steps,Convergence criteria, Role of finite element analysis in computer-aideddesign., Mathematical Preliminaries, Differential equationsformulations, Variational formulations, weighted residual methods. Basic Equations and Potential Energy Functional, 1-D Bar Element, Strain matrix, Element equations, Stiffness matrix, Consistent nodal force vector: Body force, Initial strain, Assembly Procedure, Boundary and Constraint Conditions, Single point constraint, Multi-point constraint, 2-D Bar Element.

| Module 2 | L1,L2,L3, | 08 Hrs. |
|---|---|---|

**Two-Dimensional Elements-Analysis, Three-Dimensional Elements-Applications and Problems:** Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8) . Basic Equations and Potential Energy Functional, Four-Noded Tetrahedral Element (TET 4), Eight-Nodded Hexahedral Element (HEXA 8), Tetrahedral elements, Hexahedral elements: Serendipity family, Hexahedral elements: Lagrange family. Shape functions for HigherOrder Elements.

| | | |
|---|---|---|
| **Module -3** | L1,L2,L3 | 08 Hrs. |

**Aero Structural analysis through FEM for Beams and Trusses:** 1– D Beam Element, 2–D Beam Element, shape functions and stiffness matrixes, Problems, trusses with one, two, three and four bar elements.

| | | |
|---|---|---|
| **Module -4** | L1,L2,L3, | 08 Hrs. |

**FEM analysis of Heat Transfer and Fluid Flow:** Steady state heat transfer, 1 D heat conduction governing equation, boundary conditions,One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1 D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.

| | | |
|---|---|---|
| **Module -5** | L1,L2,L3 | 08 Hrs. |

**FEM for Dynamic:** Formulation for point mass and distributed masses, Consistent element mass matrix of one-dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element. Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

**Text Books:**


1. Chandrupatla T. R.,"Finite Elements in engineering"- 2nd Edition, PHI, 2007.
2. Lakshminarayana H. V.,"Finite Elements Analysis"– Procedures in Engineering, Universities Press, 2004.


**Reference Books:**


1. Rao S. S. "Finite Elements Method in Engineering"- 4th Edition, Elsevier, 2006.
2. P.Seshu, "Textbook of Finite Element Analysis" -PHI, 2004.
3. J.N.Reddy, "Finite Element Method"- McGraw -Hill International Edition.
4. Bathe K. J. "Finite Elements Procedures"- PHI.


CO, PO Mapping

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO2 | 3 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO3 | 3 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO4 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 1 |
| CO5 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 3 | 1 |

High,3, Medium,2, Low,1

| Course Title | RESEARCH METHODOLOGY ANDIPR | Semester | I |
|---|---|---|---|
| Course Code | MVJ22MAE16 | CIE | 50 |
| Total No. of Contact Hours | 25 L : T : P :: 20 : 0 : 5 | SEE | 50 |
| No. of Contact Hours/week | 2 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

Course objective is to:

- research problem
- Learn the functions of literature review in research and research design
- Describe the art of interpretation and the art of writing research reports & IPR Acts.

| Module 1 | L1,L2,L3 | 05 Hrs. |
|---|---|---|

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration

Laboratory Sessions/ Experimental learning:

Describe the details of sampling designs, measurement and scaling techniques.

1. Study of an Experimental and Theoretical Determination of a research models.
2. Determination of Problems encountered in research

Applications: Defining Research and Doing research

Video link / Additional online information (related to module if any):

https://www.digimat.in/nptel/courses/video/121106007/L01.html

https://www.youtube.com/watch?v=EVcPmmfK1Do

| Module 2 | L1,L2,L3, | 05 Hrs. |
|---|---|---|

**Reviewing the literature**: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing

literature, reviewing the selected literature, Developing a theoretical framework, Developing aconceptual framework, Writing about the literature reviewed.

**Research Design**: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs

Laboratory Sessions/ Experimental learning:

1. Validate any Literature related to research.
2. A study of different research designs.

Applications: Proceeding to further research, Development of Model Video link / Additional online information (related to module if any):

https://nptel.ac.in/courses/121106007/

| Module 3 | L1,L2,L3 | 05 Hrs. |
|---|---|---|

**Design of Sampling**: Introduction, Sample Design, Sampling and Nonsampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.

**Measurement and Scaling**: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

**Data Collection**: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method.

Laboratory Sessions/ Experimental learning:

1. Determination of methods of collecting data for research
2. 

Qualitative and Quantitative Research, Finding out Sampling and nonsampling errors,

Video link / Additional online information (related to module if any):

https://nptel.ac.in/courses/110107080/

| Module 4 | L1,L2,L3 | 05 Hrs. |
|---|---|---|

**Testing of Hypotheses**: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis.

**Chi-square Test**: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, and Cautions in Using Chi Square Tests

Laboratory Sessions/ Experimental learning:

1.Determine the Hypothesis testing in a statistical method that is used inmaking statistical decisions using experimental data.

2.Validate chi-square test by superposition theorem.

Applications: Accuracy in testing, statistical methods.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=14PQawp_rjkhttps://nptel.ac.in/courses/103106120/

| Module 5 | L1,L2 | 05 Hrs. |
|---|---|---|

**Interpretation and Report Writing**: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

**Intellectual Property**: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act 2000, The Protection of Plant Varieties and

Farmers' Rights Act 2001. Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks.

Laboratory Sessions/ Experimental learning:

1.Determine the Technique of Interpretation & Precaution in Interpretation.

Applications: Report Writing, Intellectual Property System in India Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=Xp2PVO3do34

https://nptel.ac.in/courses/109105112/

Course outcomes:

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

| | |
|---|---|
| CO1 | Explain an overview of research methodology and explain techniques of defining a research problem |

| | |
|---|---|
| CO2 | Use the functions of literature review in research and research design. |
| CO3 | Compute the details of sampling designs, measurement and scaling techniques and also different methods of data collections |
| CO4 | Learn several parametric tests of hypotheses and Chi-square test applications |
| CO5 | Apply the art of interpretation, the art of writing research reports & to use IPR Acts |

| Reference Books: | |
|---|---|
| 1. | C.R. Kothari, Gaurav Garg, Research methodology, Methods and Techniques", New Age |
| 2. | International,4th Edition, 2018 |
| 3. | Ranjit Kumar, Research Methodology a step-by-step guide for beginners, (For the topic Reviewing the literature under module 2), SAGE Publications Ltd., 3rd Edition, 2011. |
| 4. | Study Material (For the topic Intellectual Property under module 5), Professional Programme<br>Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body under an Act of Parliament, September 2013 |
| | Garg B.L, An introduction to Research Methodology, et al ,RBSA Publishers 2002 |

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO2 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| CO3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| CO4 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 2 |
| CO5 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |

High,3, Medium,2, Low,1

| Course Title | AERODYNAMICS LAB | Semester | I |
|---|---|---|---|
| Course Code | MVJ22MAE17 | CIE | 50 |
| Total No. of Contact Hours | 40 | SEE | 50 |
| No. of Contact Hours/week | 03 | Total | 100 |
| Credits | 02 | Exam. Duration | 3 Hours |

Course objective is to:

- Be acquainted with basic principles of aerodynamics using wind tunnel.
- Acquire the knowledge on flow visualization techniques.
- Understand the procedures used for calculating the lift and drag.

| Sl No | Experiment Name | RBT Level | Hours |
|---|---|---|---|
| 1 | Calibration of test section of a subsonic wind tunnel. | L1,L2,L3 | 03 |
| 2 | Smoke flow visualization on a wing model at different angles of incidence at low speeds. | L1,L2,L3 | 03 |
| 3 | Tuft flow visualisation on a wing model at different angles of incidences at low speeds: Identify zones of attached and separated flows | L1,L2,L3 | 03 |
| 4 | Surface pressure distribution around building models in multiple model arrangement | L1,L2,L3 | 03 |
| 5 | Surface pressure distribution on a cambered wing at different angles of incidence and calculation of lift and pressure drag. | L1,L2,L3 | 03 |
| 6 | Calculation of total drag of a cambered airfoil at a low incidence using pitot-static probe wake survey | L1,L2,L3 | 03 |
| 7 | Measurement of typical boundary layer velocity profile on the wind tunnel wall (at low speeds) using a pitot probe and calculation of boundary layer displacement and momentum thickness in the presence of a circular cylinder model. | L1,L2,L3 | 03 |
| 8 | Study the effect of Blockage ratio on drag & pressure distribution of a circular cylinder | L1,L2,L3 | 03 |
| 9 | Study of pressure distribution on hemi spherical objects. | L1,L2,L3 | 03 |
| 10 | Measurement of turbulence level in a low speed wind tunnel | L1,L2,L3 | 03 |
| 11 | Study of wake behind wing under a reverse flow condition at various angles of attack & compare it with normal flow conditions | L1,L2,L3 | 03 |

| | | | |
|---|---|---|---|
| 12 | Conduct a series of test to obtain the stagnation pressure response of pitot probe in a wind tunnel for varied yaw angle and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle | L1,L2,L3 | 03 |
| 13 | To determine longitudinal static stability derivative of an aircraft configuration model at various angles of attack and side slips | L1,L2,L3 | 03 |
| 14 | To determine lateral and directional static stability derivative of an aircraft configuration model at various angles of attack and side slips | L1,L2,L3 | 03 |
| | | | |
| Course outcomes: | | | |
| CO1 | Apply the flow visualization techniques | | |
| CO2 | Estimate the pressure distribution over the bodies | | |
| CO3 | Calculate the forces and moments on models. | | |

| CO-PO Mapping | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| CO2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| CO3 | 3 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |

High-3, Medium-2, Low-1

**II SEMESTER M.Tech AE**

| S. No | Course | | Course Title | Teaching Department | Teaching hours/week | | | Examination | | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory | Practical / Seminar | Tutorial / Skill Development Activity | Self-Study Component | Duration in Hours | CIE Marks | SEE Marks | Total marks | |
| | Type | Code | | | L | T | P | S | | | | | |
| 1 | PCC | MVJ22MAE21 | Flight Mechanics | AE | 2 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 3 |
| 2 | IPCC | MVJ22MAE22 | Airframe Structures and Structural Design (+Modelling and Analysis Lab) | AE | 3 | 2 | 0 | 0 | 3 | 50 | 50 | 100 | 4 |
| 3 | PEC | MVJ22MAE23X | Professional elective -1 | AE | 2 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 3 |
| 4 | PEC | MVJ22MAE24X | Professional elective -2 | AE | 2 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 3 |
| 5 | MPC | MVJ22MAE25 | Mini Project with seminar | AE | 0 | 4 | 2 | 0 | - | 100 | - | 100 | 3 |
| 6 | PCCL | MVJ22MAEL26 | Structures Lab | AE | 1 | 2 | 0 | 0 | 3 | 50 | 50 | 100 | 2 |
| 7 | AUD/AEC | MVJ22MAE22 | (Online) | AE | Classes and evaluation procedures are as per the policy of the online course providers | | | | | | | | PP |
| **Total** | | | | | **10** | **8** | **8** | **-** | **-** | **350** | **250** | **600** | **18** |

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project With Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities (Hours are for Interaction between faculty and students) PP/NP-Passed / Not Passed (Only for non-Credit Course).

| **Professional Elective -1** | | **Professional Elective -2** | |
|---|---|---|---|
| MVJ22MAE231 | Applied Computational Fluid Dynamics | MVJ22MAE241 | Hypersonic Aerodynamics |
| MVJ22MAE232 | Fatigue and Fracture Mechanics | MVJ22MAE242 | Theory of Aero elasticity |
| MVJ22MAE233 | Aero-engine Testing and Evaluation | MVJ22MAE243 | Theory of Combustion |
| MVJ22MAE234 | Avionics | MVJ22MAE244 | Artificial Intelligence and Robotics |
| MVJ22 MAE235 | Unmanned Aerial Vehicles | MVJ22MAE245 | Helicopter Dynamics |

| Course Title | **Flight Mechanics** | Semester | II |
|---|---|---|---|

| Course Code | **MVJ22MAE21** | CIE | 50 |
|---|---|---|---|
| Total No. of Contact Hours | **40 L: T:P: 2:0:2** | SEE | 50 |
| No. of Contact Hours/week | 5 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

Course objective is to:

- Understand the steady performance of airplanes
- Understand the accelerated performance of airplane
- Acquire knowledge of static longitudinal stability of airplane
- Acquire knowledge of static directional and lateral stability of airplane
- Gain knowledge of dynamic longitudinal stability of airplanes

| Module 1 | L1,L2,L3 | 10 Hrs. |
|---|---|---|

Aircraft Performance: Aviation history. Principles of Flight. Aircraft aerodynamics; Drag and Thrust. Steady and level Flight. Variation of Thrust, Drag, Power available, and Power required with speed and altitude. Minimum drag, minimum power, Maximum and minimum level flight speeds.

**Laboratory Sessions/ Experimental learning:**

Estimation of Drag and Lift at various speeds and thereby drag polar estimation **Applications**

Applicable in standard Airplane Design

**Video link / Additional online information (related to module if any):**

https://nptel.ac.in/courses/101106041/Module 1 to Module 5

https://nptel.ac.in/courses/101104007/Module 1

| Module 2 | L1,L2,L3, | 10 Hrs. |
|---|---|---|

Steady Performance: Airplane Steady Performance: General equation of motion, Steady level flight performance, Steady Climbing, Gliding Flights; Minimum rate of sink and range in a glide. Range and Endurance of jet and piston prop airplanes.

Accelerated Performance: Estimation of take-off and landing distances. Ground effect, Balanced Field Length. Turn performance; Bank angle, load factor, pull-up & pull-down maneuver; accelerated climbing, V-n diagram. **Laboratory Sessions/ Experimental learning:**

Estimation of Drag and Lift at various turn performance

**Applications**

Applicable in standard Airplane Design

| | | |
|---|---|---|
| **Video link / Additional online information (related to module if any):**<br>https://nptel.ac.in/courses/101106041/Module 5 to Module 10<br>https://nptel.ac.in/courses/101104007/Module 1 | | |
| **Module 3** | **L1,L2,L3** | 10 Hrs. |
| Static Longitudinal Stability and Control: Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria, Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution, Power effects- Propeller airplane and Jet airplane. Trim condition. Static margin, stick fixed neutral points. Longitudinal control, Elevator power, Elevator angle versus equilibrium lift coefficient,<br>Elevator required for landing, Restriction on forward C.G. range, Hinge moment parameters, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G<br>**Laboratory Sessions/ Experimental learning**: Estimation of Static Stability Derivatives at various speeds<br>**Applications**<br>Applicable in standard Airplane Design<br>**Video link / Additional online information (related to module if any):**<br>https://nptel.ac.in/courses/101106043/Module 1 to 4<br>https://nptel.ac.in/courses/101104007/Module 3 | | |
| **Module 4** | **L1,L2,L3** | 10 Hrs. |
| Static Directional Stability and Control: Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability, Requirements for directional control, Rudder lock, Dorsal fin. One engine inoperative condition, Weather cocking effect.<br><br>Static Lateral Stability And Control: Introduction, definition of Roll stability. Estimation of dihedral effect., Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, Balancing the aileron.<br>**Laboratory Sessions/ Experimental learning**:<br>Estimation of Static stability derivatives at various speeds **Applications**<br>Applicable in standard Airplane Design<br>**Video link / Additional online information (related to module if any):**<br>https://nptel.ac.in/courses/101106043/Module 5 to Module 6<br>https://nptel.ac.in/courses/101104007/Module | | |
| **Module 5** | **L1,L2** | 10 Hrs. |

Dynamic Longitudinal Stability: Definition of Dynamic longitudinal stability: types of modes of motion: long or phugoid motion, short period motion. Airplane Equations of longitudinal motion, Derivation of rigid body equations of motion, Orientation and position of the airplane, gravitational and thrust forces, Small disturbance theory.

Dynamic Lateral and Directional Stability: Routh's criteria. Factors affecting period and damping of oscillations. Effect of wind shear.

**Laboratory Sessions/ Experimental learning:**

Estimation of Dynamic Stability Derivatives

**Applications**

Applicable in standard Airplane Design

**Video link / Additional online information (related to module if any):**

https://nptel.ac.in/courses/101106043/Module 7 to Module 11

https://nptel.ac.in/courses/101104007/

**Course outcomes:**

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

| | |
|---|---|
| CO1 | Apply knowledge to calculate steady and accelerated performance |
| CO2 | Apply knowledge to calculate steady and accelerated performance |
| CO3 | Solve problems of longitudinal static stability for stick fix and stick free condition |
| CO4 | Solve problems of lateral and traverse static stability for stick fix and stick free condition |
| CO5 | Analyse dynamic stability for rigid airframe |

**Reference Books:**


| | |
|---|---|
| 1. | Anderson J.D., Introduction to Flight, McGraw Hill, 1987 |
| 2. | Perkins, C.D., and Hage, R.E., Airplane Performance, stability and Control, John Wiley & Sons Inc, New York, 1988 |
| 3. | McCormick B.W., Aerodynamics, Aeronautics and Flight Mechanics, John Wiley & Sons New York, 1979. |
| 4. | Anderson J.D., Foundation of Aerodynamics, McGraw Hill Book Co, New York,1985. |

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | **AIRFRAME STRCTURES AND STRCTURAL DESIGN + MODELLING AND ANALYSIS LAB** | Semester | II |
|---|---|---|---|
| Course Code | MVJ22MAE22 | CIE | 50 |
| Total No. of Contact Hours | 50 L : T : P :: 3: 2: 0 | SEE | 50 |
| No. of Contact Hours/week | 5 | Total | 100 |
| Credits | 4 | Exam. Duration | 3 Hrs. |

Course objective is to:

1. Understand the fundamentals of structural analysis of airframe parts.
2. Acquire knowledge on practical aircraft stress analysis.
3. structures and design against fatigue.
4. Acquire knowledge on Wing box structure and Fuselage.
5. Acquire knowledge on Empennage structure, Landing gear and engine mounts

| Module 1 | L1,L2,L3 | 10 Hrs. |
|---|---|---|

Fundamentals of structural analysis and structural components of aircraft: Basic elasticity, Two dimensional problems in elasticity, Loads on structural components, function of structural components, fabrication of structural components, connections, numerical Statically determinate and indeterminate structures as applied to aircraft structures: Statically determinate: Equilibrium of force systems, truss structures, externally braced wings, landing gear, beams – shear and moments, torsion stresses and deflection. Statically indeterminate structures: Bending moment in frames and rings by elastic centre method, Continuous structure – moment distribution method. Numerical problems

Laboratory Sessions/ Experimental learning: Analysis of truss elements for different loading conditions using Ansys

Applications: For determinate and indeterminate structures.

Video link / Additional online information (related to module if any): https://cosmolearning.org/courses/introduction-aerospace-structures/

| Module 2 | L1,L2,L3, | 10 Hrs. |
|---|---|---|

Introduction to practical aircraft stress analysis: Introduction to wing stress analysis by modified beam theory, Introduction to fuselage stress analysis by modified beam theory, Loads and stresses on ribs and frames. Numerical problems.

Laboratory Sessions/ Experimental learning: Deflection of a Simply Supported Beam.
Applications: Modified beam theory for wing and fuselage stress analysis. Video link / Additional online information (related to module if any): https://cosmolearning.org/courses/introduction-aerospace-structures/

| Module 3 | L1,L2,L3 | 10 Hrs. |
|---|---|---|

Buckling and stability as applied to aircraft structures: Introduction, columns and beam columns, crippling stress, buckling of this sheets, Thin skin-stringer panels, skin-stringer panels, Integrally stiffened panels. Numerical problems, Overview of structural design process: Structural integrity, Material and mechanical properties, failure theories, Design criteria- safe life and fail safe, Designing against fatigue, prediction of aircraft fatigue life.

Laboratory Sessions/ Experimental learning:
Buckling load of slender Eccentric Columns and Construction of Southwell Plot
Applications: Structural design process
Video link / Additional online information (related to module if any): https://cosmolearning.org/courses/introduction-aerospace-structures/

| Module 4 | L1,L2,L3 | 10 Hrs. |
|---|---|---|

Wing box structure and Fuselage: Introduction, wing box design, wing covers, spars, Ribs and bulkheads, wing root joints, variable swept wings, wing fuel tank design. Fuselage: Introduction, fuselage configuration, fuselage detail design, forward fuselage, wing and fuselage intersection, stabilizer and aft fuselage intersection, fuselage opening
Standard topology optimisation as applied to airframe parts.
Laboratory Sessions/ Experimental learning:
Determination of shear centre for open and closed sections Applications: Aircraft wings and fuselage.
Video link / Additional online information (related to module if any):
https://cosmolearning.org/courses/introduction-aerospace-structures/

| Module 5 | L1,L2 | 10 Hrs. |
|---|---|---|

Empennage structure, Landing gear and engine mounts: Landing gear: Empennage structure: Introduction, Horizontal stabilizer, vertical stabilizer, elevator and rudder. Introduction, developments and arrangements, stowage and retraction, detail design. Engine mounts: Introduction, propeller driven engine mounts, inlet of jet engines, wing-pod (pylon) mounts, rear fuselage mounts and tail mounts, fuselage mounts (fighters).

Laboratory Sessions/ Experimental learning: Study on Empennage structure.

Applications: Aircraft empennage, landing gear and engine mounts. Video link / Additional online information (related to module if any): https://cosmolearning.org/courses/introduction-aerospace-structures/

**Course outcomes:**

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

| | |
|---|---|
| CO1 | Apply fundamentals of structural analysis of airframe parts |
| CO2 | Demonstrate knowledge of practical aircraft stress analysis. |
| CO3 | Analyse Buckling and stability as applied to aircraft structures and design against fatigue |
| CO4 | Demonstrate knowledge of Wing box structure and Fuselage. |
| CO5 | Demonstrate knowledge of Empennage structure, Landing gear and engine mounts |

**Reference Books:**


| | |
|---|---|
| 1. | T.H.G. Megson, 'Aircraft structures for engineering students', fourth edition, ButterworthHeinemann, USA, 2007 |
| 2. | Michael Chun-Yung Niu, Airframe structural design, Lockheed Aeronautical systems company, Burbank, California, Hong Kong Conmilt Press Ltd, USA, February 2002 |
| 3. | Peery D. J. and Azar J. J. , Aircraft Structures, 2nd edition, McGraw Hill N.Y.,1993 |
| 4. | E.F. Bruhn, 'Analysis and design of flight vehicle structures', Jacobs Publishing, Inc, USA, 1973 |


**CO, PO Mapping**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **Course Title** | MODELING AND ANALYSIS LAB | **Semester** | II |
| **Course Code** | MVJ22MAE22 | **CIE** | 50 |
| **Total No. of Contact Hours** | 30 | **SEE** | 50 |
| **No. of Contact Hours/week** | 03 | **Total** | 100 |
| **Credits** | 02 | **Exam. Duration** | 3 Hours |

- **Course objective is to:**
- Understand the procedure to draw the geometric models of symmetric, cambered aerofoil, nozzle, wingand other structures.
- Acquire the knowledge of types of meshing.
- Understand the basics of flow and stress analysis.

| Sl No | Experiment Name | RBT Level | Hours |
|---|---|---|---|
| **1** | Modeling of Symmetrical/Cambered Aerofoil Geometry, and Generation of Body Fitting AdaptiveMesh. | L1,L2,L3 | 03 |
| **2** | Modeling of 2-D Incompressible and Inviscid Flow over Symmetrical/Cambered Aerofoil, and Plottingof Pressure distribution and Velocity vectors for Subsonic/Supersonic Mach numbers. | L1,L2,L3 | 03 |
| **3** | Modeling of 2-D Compressible and Viscid Flow over Symmetrical/Cambered Aerofoil and Plotting ofPressure distribution and Velocity vectors for Subsonic Mach numbers. | L1,L2,L3 | 03 |
| **4** | Isentropic Flow Analysis in a 2-D Subsonic Diffuser and a Subsonic Nozzle. | L1,L2,L3 | 03 |
| **5** | Isentropic Flow Analysis in a 2-D Supersonic Diffuser and a Supersonic Nozzle. | L1,L2,L3 | 03 |
| **6** | Geometric Modeling and Mesh Generation of a 2-D Convergent-Divergent Nozzle and Analyses of flow for Adiabatic Conditions (Fanno Flow). | L1,L2,L3 | 03 |
| **7** | Geometric Modeling and Mesh Generation of a 2-D Pipe and Modeling of Steady/Unsteady Heat Convection and Conduction (Rayleigh Flow). | L1,L2,L3 | 03 |
| **8** | Structural Modeling of Sandwich Beam of Rectangular Cross-section and Analyses for Stress for Unsymmetrical bending case | L1,L2,L3 | 03 |
| **9** | Structural Modeling and Stress Analysis of a Torsion Box of a Wing. | L1,L2,L3 | 03 |
| **10** | Structural Modeling and Stress Analysis of a Fuselage Frame. | L1,L2,L3 | 03 |
| **11** | Structural Modeling and Stress Analysis of a Tapered I-Section Spar. | L1,L2,L3 | 03 |
| **12** | Determine the Natural frequency and Mode shapes of a Cantilever beam under UDL. | L1,L2,L3 | 03 |
| **13** | A Plate fixed at one end has a hole in centre and has varying thickness, Determine stresses developed due to applied static loads in vertical direction. | L1,L2,L3 | 03 |
| **14** | A Tapered Plate fixed at one end has a hole in centre and has varying thickness, determine stressesdeveloped due to applied static loads in vertical direction. | L1,L2,L3 | 03 |

| **Course outcomes:** | |
|---|---|
| CO1 | Draw the geometric models of symmetric, cambered aerofoil, nozzle, wing and other structures. |
| CO2 | Apply different types of meshing. |
| CO3 | Perform the flow and stress analysis. |

| **CO-PO Mapping** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

High-3, Medium-2, Low-1

| | | | |
|---|---|---|---|
| Course Title | APPLIED COMPUTATIONAL FLUID DYNAMICS | Semester | II |
| Course Code | MVJ22MAE231 | CIE | 50 |
| Total No. of Contact Hours | **40 L: T:P: 2:0:2** | SEE | 50 |
| No. of Contact Hours/week | 5 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

Course objective is to:

- Understand CFD ideas and Mathematical behaviour of PDEs
- Acquire the knowledge to solve CFD problems through finite difference discretisation
- Gain knowledge for grid generation and optimize grids
- Acquire the knowledge to solve CFD problems through finite volume technique

| Module 1 | L1,L2,L3 | 10 Hrs. |
|---|---|---|

Introduction: CFD ideas to understand, CFD Application, Models of flows, Substantial derivative, Divergence of velocity. Governing Equations (no derivation) of flow; continuity, momentum, energy. Physical Boundary conditions. Conservative & Non-conservative forms of equations, Integral vrs Differential Forms of Equations. Form of Equations particularly suitable for CFD work. Shock capturing, Shock fitting. Mathematical Behavior of Partial Differential Equations: Classification of partial differential equations – Cramer Rule, Eigenvalue method. Equations of mixed type. Classification Impact on Physical & Computational Fluid Dynamics: Case studies.
Laboratory Sessions/ Experimental learning: Ansys Lab
Applications: Choice of PDE vis a vis Flow behavior
Video link / Additional online information (related to module if any):
Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur

| Module 2 | L1,L2,L3, | 10 Hrs. |
|---|---|---|

Discretization: Essence of discretization- Finite difference quotient, solution process, Reflection Boundary condition. Difference equation-Explicit and Implicit approach. Errors and stability analysis. Stability regions of standard time –steeping techniques. Solution of finite difference equations; Time marching and Space marching. Upwind and Mid-point leap frog schemes. shock capturing, Numerical viscosity, artificial viscosity. Relaxation technique; successive over relaxation/ successive under relaxation. Alternating Direction Implicit (ADI) Method. Lax – Wendroff second order scheme (without and with artificial viscosity). Effect of conservative smoothing. Unsteady problem-Explicit versus Implicit Scheme.

| | | |
|---|---|---|
| Laboratory Sessions/ Experimental learning: Ansys Lab<br>Applications: Flow analysis using Finite Difference Techniques<br>Video link / Additional online information (related to module if any):<br>Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur | | |
| **Module 3** | L1,L2,L3 | 10 Hrs. |
| Grid Generation: Structured Grid Generation:-Algebraic Methods, Numerical grid generation methods, Surface grid generation, Multi Block Structured gridgeneration. Unstructured Grid Generation:- Delaunay-Voronoi Method, advancing front methods (AFM) Modified for Quadrilaterals, iterative paving method, Quadtree& Octree method. Multi-grid methods (Cycling Strategies). PDE mapping methods, use of grid control functions, and Chimera grids.<br>Laboratory Sessions/ Experimental learning: Ansys Lab<br>Applications: Body fitting Grid generation<br>Video link / Additional online information (related to module if any): Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur | | |
| **Module 4** | L1,L2,L3 | 10 Hrs. |
| Adaptive Grid Methods: Adaptive Structured Grid Generation, Unstructured adaptive grid Methods. Mesh refinement methods, and Mesh enrichment method. Unstructured Finite Difference mesh refinement. Approximate Transformation & Computing Techniques: Matrices & Jacobian. Generic form of governing Flow Equations with strong conservative form in transformed space. Transformation of Equation from physical plane into computational Plane - examples. Control function methods. Variation Methods. Domain decomposition. Need for Parallel Computing in CFD algorithms.<br>Laboratory Sessions/ Experimental learning: Ansys Lab<br>Applications: Adaptive Grid formulation<br>Video link / Additional online information (related to module if any):<br>Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur | | |
| **Module 5** | L1,L2 | 10 Hrs. |
| Finite Volume Techniques: Spatial discretisation:-Cell Centered Formulation and Cell vertex Formulation. Temporal discretisation:- Explicit time-stepping and Implicit time- stepping, time step calculation, Boundary conditions Case studies- Laplace equation, Diffusion problem, Convection and diffusion, Unwinding scheme, and Unsteady flows. High Resolution schemes-Total variation diminishing scheme, Hybrid differencing scheme, weighted essentially non-oscillatory scheme, artificial dissipation, and flux limiters. CFD Application to Some Problems: Aspects of numerical dissipation & dispersion. Approximate factorization, Flux Vector | | |

splitting. Application to Turbulence-Models. Large eddy simulation, Direct Numerical Solution. Computational solution to turbulent and laminar boundary layers. Heat through conduction and radiation. Post-processing and visualization, contour plots, vector plots etc.

Laboratory Sessions/ Experimental learning: Ansys Lab

Applications: Flow analysis through Finite Volume Technique

Video link / Additional online information (related to module if any):

Nptel Video: CFD by Prof. S Chakraborty IIT Kharagpur

Course outcomes:

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

| | |
|---|---|
| CO1 | Apply knowledge of CFD ideas, and Flow Equations |
| CO2 | Assimilate Mathematical behaviour of PDEs vis a vis nature of flow |
| CO3 | Utilise finite difference techniques. |
| CO4 | Generate &Utilise grids |
| CO5 | Apply finite volume techniques |

Reference Books:


| | |
|---|---|
| 1. | F. Wendt (Editor), Computational Fluid Dynamics - An Introduction, Springer – Verlag, Berlin; 1992. |
| 2. | Charles Hirsch, Numerical Computation of Internal and External Flows, Vols. I and II. John Wiley & Sons, New York; 1988. |
| 3. | Fletcher, C.A.J, Computational Techniques for Fluid Dynamics, Springer, Berlin,2nd edition, 2002,ISBN-13: 978-3540543046 |
| 4. | Tapan K. Sengupta, Fundamentals of CFD, Universities Press, 2004. |


CO, PO Mapping

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | - | 1 |
| CO2 | 3 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | - | 1 |
| CO3 | 3 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | - | 1 |
| CO4 | 3 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | - | 1 |
| CO5 | 3 | 3 | 2 | 2 | 1 | - | - | 1 | 1 | 1 | 1 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | FATIGUE AND FRACTURE MECHANICS | Semester | II |
|---|---|---|---|
| Course Code | MVJ22MAE232 | CIE | 50 |
| Total No. of Contact Hours | 40 L: T:P: 2:0:2 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

- Understand the basics of fatigue of structures.
- Understand the Statistical Aspects of Fatigue Behaviour
- Acquire knowledge of Physical Aspects of Fatigue
- Understand concepts of equations of Fracture Mechanics
- Comprehend the various Fatigue Design and Testing Procedures.

| **Module 1** | **L1,L2** | 10 Hrs. |
|---|---|---|

**Fatigue of Structures:**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.Plane stress and plane strain concepts, Dugdale approach

**Laboratory Sessions/ Experimental learning:**

Effect of Stress concentration factors and SNcurves plot in strength of materials lab

**Applications:**

Determine the Endurance limit and Stress concentration factors

**Video link / Additional online information (related to module if any):**

NPTEL-

1. https://nptel.ac.in/courses/112/106/112106065/
2. https://www.youtube.com/watch?v=o-6V_JoRX1g

| **Module 2** | **L1, L2** | 10 Hrs. |
|---|---|---|

**Statistical Aspects of Fatigue Behaviour:**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,Fatigue loading,Various stages of crack propagation

**Laboratory Sessions/ Experimental learning:**

Experimental verification of the components can be done for Low cycle and high cycle fatigue

**Applications:**

Determine the cumulative damage of the material

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/

| **Module 3** | **L1, L2** | 10Hrs. |
|---|---|---|

**Physical Aspects of Fatigue:**Phase in fatigue life, Crack initiation, Crack growth, Final fracture,

Dislocations, Fatigue fracture surfaces.Crack opening displacement,crack tip opening displacement.

**Laboratory Sessions/ Experimental learning:**

To determine the crack initiation and crack growth of the given material using equipment setup.

**Applications:**

To determine the COD and CTOD values of the given material

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/

| **Module 4** | **L1, L2** | 10 Hrs. |
|---|---|---|

**Fracture Mechanics:** Strength of cracked bodies, potential energy and surface energy, Griffith's theory, Irwin – Orwin extension of Griffith'stheory to ductile materials, Stress analysis of cracked bodies, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries, Linear elastic fracture mechanics.

**Laboratory Sessions/ Experimental learning:**

Estimate the effect of stress intensity factors and effect of thickness on fracture toughness.

**Applications:**

To find out the stress analysis of the cracked bodies

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/

| **Module 5** | **L1, L2** | 10 Hrs. |
|---|---|---|

**Fatigue Design and Testing**: Safe life and fail safe design philosophies,Importance of Fracture Mechanics in aerospace structure, Application composite materials and structures.

**Laboratory Sessions/ Experimental learning:**

Determine short period and phugoid oscillations for a given Quadratic equation

**Applications:**

Determinethe relative stability of an Aircraft

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/112/106/112106065/

**Course outcomes:**

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

| | |
|---|---|
| CO403.2.1 | Apply the concept of Fatigue analysis of the structures |
| CO403.2.2 | Compare the low cycle fatigue and high cycle fatigue and strain hardening and softening |
| CO403.2.3 | Investigate the reasons for crack initiation, growth, and fracture and for COD and CTOD |
| CO403.2.4 | Evaluate Fracture Toughness |
| CO403.2.5 | Analyse Design for Fatigue |

| Reference Books: | |
|---|---|
| 1. | D. Brock, Elementary Engineering Fracture Mechanics,Noordhoff International Publishing Co.,London, 1994 |
| 2. | J.F. Knott, Fundamentals of Fracture Mechanics, Butterworth & Co., Publishers Ltd., London,1983. |
| 3. | W. Barrois and L. Ripley, Fatigue of Aircraft Structures, Pergamon Press, Oxford, 1983 |
| 4. | C.G.Sih, Mechanics of Fracture, Vol.1 Sijthoff and Noordhoff International Publishing Co.,<br>Netherland, 1989. |

**CIE Assessment:**

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

**SEE Assessment:**

i. Question paper for the SEE consists of two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

ii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

iii. One question must be set from each unit. The duration of examination is 3 hours.

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

High,3, Medium,2, Low,

| | | | |
|---|---|---|---|
| **Course Title** | **AERO-ENGINE TESTING AND EVALUATION** | **Semester** | **II** |
| **Course Code** | **MVJ22MAE23** | **CIE** | **50** |
| **Total No. of Contact Hours** | **40 L: T:P: 2:0:2** | **SEE** | **50** |
| **No. of Contact Hours/week** | **4** | **Total** | **100** |
| **Credits** | **3** | **Exam. Duration** | **3 Hrs.** |

**The course objective is to:**

1. solve problems related to aerothermodynamics of compressors, combustors, and turbines
2. Apply knowledge to test engines
3. Specify engine performance requirements

| **Module 1** | **L1,L2** | 10 Hrs. |
|---|---|---|

**Introduction:** Need for Gas Turbine Engine Testing And Evaluation, Philosophy Of Testing, Rationale Of Testing. Types of tests: Proof of Concepts, Design Verification, Design Validation, and Formal Tests. Aero Thermodynamic Tests: Compressor: Compressor scaling parameter Groups, Compressor MAP. Inlet distortions. Surge margins stack up. Testing and Performance Evaluation, Test rig.

**Applications:** To understand the different types of Engines and Working.

**Video link / Additional online information (related to module if any):**

Gas Dynamics and Propulsion by Prof. V. Babu,Department of Mechanical Engineering,IIT Madras.

https://youtu.be/30-FdRgygI0

https://youtu.be/iKLRgAgfjKE

Aircraft Propulsion Course URL: https://swayam.gov.in/nd1_noc19_me76/... Prof. Vinayak N. Kulkarni Dept. of Mechanical Engineering IIT Guwahati

https://youtu.be/7WFBBE2sKHE

| **Module 2** | **L1,L2,L3,** | 10 Hrs. |
|---|---|---|

**Combustor: Combustor MAP, Pressure loss, combustion light up test. Testing and Performance Evaluation.**

**Aero Thermodynamic Tests: Turbines: Turbine MAP. Turbine Testing and Performance Evaluation. Component model scaling. Inlet duct & nozzles: Ram pressure recovery of inlet duct. Propelling nozzles, after burner, maximum mass flow conditions. Testing and Performance Evaluation.**

**Video link / Additional online information (related to module if any):**

Jet Aircraft Propulsion by Prof. Bhaskar Roy and Prof. A. M. Pradeep, Department of Aerospace Engineering, IIT Bombay.

1. https://youtu.be/AOmo98peh6I

| **Module 3** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

**Engine performance:** Design & off-design Performance. Transient performance. Qualitative

characteristics quantities. Transient working lines. Starring process & Wind milling of Engines. Thrust engine start envelope. Calculations for design and off-design performance from given test data – (case study for a Jet Engine).

**Applications:**To understand the performance characteristics of gas turbine engines.

**Video link / Additional online information (related to module if any):**

Jet Aircraft Propulsion by Prof. Bhaskar Roy and Prof. A. M. Pradeep, Department of Aerospace Engineering, IIT Bombay.

https://youtu.be/AOmo98peh6I

| **Module 4** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

**Qualification Tests:** Tests used to evaluate a design. Environment ingestion capability. Preliminary flight rating tests, Qualification testing, acceptance tests, Reliability figure of merit. Structural integrity tests: Design Verification Tests, Durability and Life Assessment Tests, Reliability Tests, Failure Simulation Tests, Functional and Operability Tests. Types of engine tests: Normally Aspirated Testing, Ram Air Testing, Altitude Testing, Flying Test Bed, Mission Oriented Tests, Open Air Test Bed, Ground Testing of Engine Installed in Aircraft, Flight testing.

**Applications:**

1.To understand the properties of fuels used in gas turbines

2. To understand the various fuel, oil and starting systems

**Video link / Additional online information (related to module if any):**

1. Gas Dynamics and Propulsion by Prof. V. Babu,Department of Mechanical Engineering,IIT Madras.

https://youtu.be/v7UJBqmsNWw

| **Module 5** | **L1,L2** | 10 Hrs. |
|---|---|---|

**Test cell:** Air breathing engine test facility. Direct connect altitude cell, propulsion wind tunnels. Types of engine test beds. Factors for design of engine test beds. Altitude test facility. Steps in test bed cross calibration. Engine testing with simulated inlet distortions. Surge test. Cell Calibration and Correction. Performance Reduction Methodology. Instrumentation: Data Acquisition, Measurement of Thrust, Pressure, Temperature, Vibration, etc.

**Accuracy and Uncertainty in Measurements. Experimental Stress Analysis.**

**Applications:** To understand the standard flight testing procedures.

**Video link / Additional online information (related to module if any):**

Introduction to Various Aircraft engines, Engine Performance parameters Aircraft Propulsion Course URL: https://swayam.gov.in/nd1_noc19_me76/...Prof. Vinayak N. Kulkarni Dept. of Mechanical Engineering IIT Guwahati

https://youtu.be/BT9oq73VxC4

**Course outcomes:**

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

| | |
|---|---|
| CO312.2.1 | solve problems related to aerothermodynamics of compressors, combustors, and turbines |

| | |
|---|---|
| CO312.2.2 | Apply knowledge to test engines |
| CO312.2.3 | Specify engine performance requirements |

| Reference Books: | |
|---|---|
| 1. | Gas Turbine Performance P.P Walsh and P. Peletcher Blackwell Science1998 |
| 2. | Experimental methods for Engineers J P Holman Tata McGraw –Hill Publishing Co. Ltd 2007 |
| 3. | Advance Aero-Engine Testing, AGARD-59Publication |

CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

- Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.
- Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.
- One question must be set from each unit. The duration of examination is 3 hours.

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 2 | 2 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 2 | 3 | 3 | 1 | 0 | 0 | 0 | 1 | 2 | 2 | 1 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 2 | 1 | 2 | 1 | 1 |
| CO5 | 3 | 3 | 2 | 2 | 3 | 1 | 0 | 0 | 0 | 2 | 2 | 2 | 1 | 1 |

High,3, Medium,2, Low,1

| Course Title | AVIONICS | Semester | II |
|---|---|---|---|
| Course Code | MVJ22MAE234 | CIE | 50 |
| Total No. of Contact Hours | 40 L: T:P: 2:0:2 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**Course objective is to:**

This course will enable students to

1. Understand the need for avionics in civil, military and space systems.
2. Acquire the knowledge of control and navigation systems
3. Acquire the knowledge of display technologies and avionics system architectures
4. Appreciate the use of microprocessors
5. Understand the functioning of data buses

| **Module 1Power Distribution System** | **L1,L2** | 10 Hrs. |
|---|---|---|

**Power Distribution System:** Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Need for Avionics in civil and military aircraft.

**Laboratory Sessions/ Experimental learning:** Programming using microprocessor

**Applications:** Data Transfer, Communication

**Video link / Additional online information (related to module if any):**

1. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

| **Module 2Inertial Navigation & Electronic Flight Control System** | **L1,L2,L3,** | 10 Hrs. |
|---|---|---|

**Inertial Navigation System:** Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing.

**Electronic Flight Control System:** Fly-by-wire system: basic concept and features. Pitch and Roll rate: command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.

**Laboratory Sessions/ Experimental learning:** Validation of truth tables for different logic circuits

**Applications :**Communication, Tracking

**Video link / Additional online information (related to module if any):**

1. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

| **Module 3Electronic Flight Instrument & Avionics Sub Systems** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

**Electronic Flight Instrument Systems:** Display-units, presentation, failure, and annunciation. Display of air data.
**Introduction to Avionics Sub Systems and Electronic Circuits:** Typical avionics sub systems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.
**Laboratory Sessions/ Experimental learning:** Construct 7 segment display circuit using IC timer
**Applications:** Attitude Estimation, Navigation, Control
**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/106/101106042/

| **Module 4Digital Systems & Flight Deck and Cockpits** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

**Principles of Digital Systems:** Digital Computers, Microprocessors, Memories.

**Flight Deck and Cockpits:** 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, and HOTAS.

**Laboratory Sessions/ Experimental learning:**Data transfer using ARINC420 data bus

**Applications:** Position Estimation, Guidance, Control

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/108/101108056/
2. https://nptel.ac.in/courses/101/108/101108056/

| **Module 5Avionics Systems Integration** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

**Avionics Systems Integration:** Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD1553B

**Laboratory Sessions/ Experimental learning:**Data transfer using MIL-STD 1553B Data bus

**Applications:** Navigation, Guidance, Control

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/106/101106042/

**Course outcomes:**

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

| | |
|---|---|
| CO404.1.1 | Understand the necessity of avionics in civil, military and space systems |
| CO404.1.2 | Understand the various aircraft navigation and control schemes |
| CO404.1.3 | Appreciate the use of electronics packages in avionics |
| CO404.1.4 | Understand the principles of various man machine interface devices such as data entry and displays. |
| CO404.1.5 | Get introduced with the avionics systems and work with the various existing aircraft data buses. |

Reference Books:


| | |
|---|---|
| 1. | R.P.G. Collinson, Introduction to Avionics Systems, 3rd Edition, 2011, Springer. |
| 2. | Ian Moir, Allan Seabridge and Malcolm Jukes, Civil Avionics Systems, 2nd Edition, 2003, |

| | |
|---|---|
| | Wiley. |
| 3. | R. Cundy Dale, Introduction to Avionics, 2010, Pearson Education. |

**CIE Assessment:**

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

**SEE Assessment:**

iv. Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.

v. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.

vi. One question must be set from each unit. The duration of examination is 3 hours.

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | | | | | | | | 2 | | | | 2 | 3 | 2 |
| CO2 | | | | | | | | | | | | 2 | 1 | |
| CO3 | 2 | 2 | 2 | | | | | | | | | 2 | | |
| CO4 | 3 | 3 | 2 | | | 2 | 2 | | | | | 3 | 2 | 1 |
| CO5 | 3 | 3 | 3 | | | 2 | 2 | | | | | 3 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | UNMANNED AERIAL VEHICLES | Semester | II |
|---|---|---|---|
| Course Code | MVJ22MAE235 | CIE | 50 |
| Total No. of Contact Hours | 40 L: T:P: 2:0:2 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

1. Comprehend the basic aviation history and UAV systems
2. Understand the air vehicle basic aerodynamics and performance
3. Acquire knowledge ofStability and Control
4. Understand concepts of Propulsion, Loads and Structures
5. Comprehend the various Mission Planning and Control

| **Module 1** | **L1,L2,L3** | 10Hrs. |
|---|---|---|

Introduction to Aviation, Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology UAVs, UAV fundamentals, Examples of UAV systems-very small, Small UAV, Medium UAV, Large UAV, UAV applications.

**Laboratory Sessions/ Experimental learning:**

Design and development of Unmanned Aerial vehicle for real world applications.

**Applications:**

Usage of UAV systems for Aerial monitoring, surveillance systems

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2. NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 2** | **L1,L2,L3,** | 10Hrs. |
|---|---|---|

**Introduction**: The Air Vehicle Basic Aerodynamics, Basic Aerodynamics equations, Aircraft polar, The real wing and Airplane, Induced drag, The boundary layer, Flapping wings, Total Air-Vehicle Drag, Performance: Overview,Climbing flight, Range for propeller driven aircraft,Range- a jet-driven aircraft, Endurance-for propeller driven aircraft,Guiding Flight.

**Laboratory Sessions/ Experimental learning:**

Conduct the various experiments using the Aerodyanamics lab and its equations.

**Applications:**

Determine the endurance limit for propeller driven shaft.

**Video link / Additional online information (related to module if any):**

1. NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2. NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 3** | **L1,L2,L3** | 10Hrs. |
|---|---|---|

**Stability & Control**: Stability, Longitudinal, lateral, Dynamic stability, Aerodynamics control, Pitch control, lateral control, Autopilots, sensor, Controller, actuator, Airframe control, Inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.

**Laboratory Sessions/ Experimental learning:**

Determine the longitudinal, lateral and dynamic stability using the Aerodynamics control.

**Applications:**

Various sensors used for the Autopilot system and control systems.

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2.NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 4** | **L1,L2,L3** | 10Hrs. |
|---|---|---|

**Propulsion Overview:** Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine,Electric Motors, Sources of Electrical Power.

**Structures**: Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials Resin Materials, CoreMaterials& Construction Techniques.

**Laboratory Sessions/ Experimental learning:**

Determine the efficiency of the various types of engines used in the Unmanned Aerial Vehicle

**Applications:**

Usage of various applications of the resin material and skin reinforcing materials for the aircraft constructions.

**Video link / Additional online information (related to module if any):**

**1.**NPTEL- https://nptel.ac.in/courses/101/104/101104073/

**2.**NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 5** | **L1,L2** | 10Hrs. |
|---|---|---|

Mission Planning and Control, Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch, Recovery Trade-offs.

**Laboratory Sessions/ Experimental learning:**

Determine the various payloads used for the various operations of flight

**Applications:**

Usage of launch and recovery systems used in the Unmanned Aerial Vehicle

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2.NPTEL- https://nptel.ac.in/courses/101/104/101104083/

**Course outcomes:**

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

| | |
|---|---|
| CO312.3.1 | Apply the basic concepts of UAV systems |
| CO312.3.2 | Utilise the knowledge of air vehicle basic aerodynamics and performance |

| | |
|---|---|
| CO312.3.3 | Apply the knowledge of Stability and Control |
| CO312.3.4 | Evaluate the Propulsion systems, Loads and Structures |
| CO312.3.5 | Apply the mission, planning and control |

| Reference Books: | |
|---|---|
| 1. | Paul Gerin Fahlstrom , Thomas James Gleason, INTRODUCTION TO UAV SYSTEMS, 4th Edition, Wiley Publication, 2012 John Wiley & Sons, Ltd |
| 2. | Landen Rosen, Unmanned Aerial Vehicle, Publisher: Alpha Editions, ISBN 13 : 9789385505034. |
| 3. | Unmanned Aerial Vehicles: DOD"s Acquisition Efforts, Publisher : Alpha Editions, ISBN13 : 9781297017544 |

| CIE Assessment: |
|---|
| CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests<br>- Quizzes/mini tests (4 marks)<br>- Mini Project / Case Studies (8 Marks)<br>- Activities/Experimentations related to courses (8 Marks) |
| SEE Assessment: |
| - Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.<br>- Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.<br>- One question must be set from each unit. The duration of examination is 3 hours. |

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

High,3, Medium,2, Low

| | | | |
|---|---|---|---|
| Course Title | HYPERSONIC AERODYANAMICS | Semester | II |
| Course Code | MVJ22MAE241 | CIE | 50 |
| Total No. of Contact Hours | **40 L: T:P: 2:0:2** | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

Course objective is to:

- Understand basic theory of hypersonic flight
- Acquire knowledge of viscous effects in high speed aerodynamics
- Gain knowledge of hypersonic test requirements

| Module 1 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

General Considerations. Characteristics General features of hypersonic flow field. Assumptions underlying inviscid hypersonic theory. Normal shock waves, oblique & curved shocks. Mach number independence principles. General strip theory. Laboratory Sessions/ Experimental learning:

Producing a normal shock waves using a shock tube and studying the pressure and temperature behind it.

Applications:

1. A hypersonic wind tunnel is designed to generate a hypersonicflow field in the working section, thus simulating the typical flow features of this flow regime - including compression shocks and pronounced boundary layer effects, entropy layer and viscous interaction zones and most importantly high total temperatures of the flow. The speed of these tunnels varies from Mach5 to 15.
2. 

pressures to 21 MPa and temperatures to 1400K.

Video link / Additional online information (related to module if any) :

https://www.youtube.com/watch?v=j493HvCkMbM

| Module 2 | L1,L2,L3, | 08 Hrs. |
|---|---|---|

Small Disturbance Theory. Slightly blunted slender bodies, large incidence & correlation of Similitude. Unsteady flow theory. Non equilibrium effects. Newtonian Theory. Twodimensional axis symmetric bodies, simple shapes & free layers. Optimum shapes, shock layer structure.

**Laboratory Sessions/ Experimental learning:**

Experimental leanings to study two dimensional axi-symmetric bodies and simple shapes subjected to hypersonic flow in hypersonic wind tunnel.

**Applications:**

To determine the unsteady flow over two dimensional axi-symmetric bodies and simple shapes for a space vehicle re-entry.

**Video link / Additional online information (related to module if any) :**

https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101105024/lec36.pdf

| Module 3 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Newtonian Theory. Shock layer structure with cross flow. Conical flow, bodies of revolution at small incidences. Theory of Thin Shock Layers. Basic concepts, successive approximation schemes. Constant stream tube-area approximation. Two-dimensional axis symmetric blunt faced bodies.

**Laboratory Sessions/ Experimental learning:**

Experiment to study the melting of models due to aerodynamic heating at hypersonic wind tunnel.

**Applications:**

1. Re-entry of space vehicles.
2. Most controlled objects enter at hypersonic speeds due to their sub-orbital (e.g., intercontinental *ballistic* missile *re-entry vehicles*), orbital (e.g., the Soyuz), or unbounded (e.g., meteors) trajectories. Various advanced technologies have been developed to enable atmospheric *re-entry* and flight at extreme velocities.
3. Study of objects entering an atmosphere from spaceat high velocities relative to the atmosphere will cause very high levels of heating.

**Video link / Additional online information (related to module if any) :**

https://www.youtube.com/watch?v=rPks77igQ0I

| Module 4 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Viscous Flows. Hypersonic Viscous effects, Boundary Layer equations. Similar laminar boundary layer solutions. Local similarity concept. Viscous interactions - flow models and interaction parameters. Weak pressure interaction. Strong pressure interaction. General features of rarified gas flows.

**Laboratory Sessions/ Experimental learning:**

Shock tunnel testing of materials subjected to unsteady with supersonic and hypersonic flows.

**Applications:**

Shock tunnels to study about weak and strong pressure interactions.

https://m.youtube.com/watch?v=6wWYKQirmJ4

| Module 5 | L1,L2 | 08 Hrs. |
|---|---|---|

Hypersonic Testing. Hypersonic Scaling, high enthalpy & high speed, types of hypersonic facilities. Shock tunnels & expansion tubes. Features of Hypersonic wind tunnel design. Instrumentation to hypersonic vehicle testing. Test model similarity laws. **Laboratory Sessions/ Experimental learning:**

Experiment to test materials at high enthalpy shock tunnel **Applications:**

Material testing during high speed flows upto supersonic and hypersonic level in shock tunnel.

**Video link / Additional online information (related to module if any) :**

https://m.youtube.com/watch?v=NXP3VZ7

**Course outcomes:**

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

| | |
|---|---|
| CO1 | Analyse hypersonic flow problems. |
| CO2 | Solve problems related to viscous and shock wave interaction. |
| CO3 | Perform hypersonic wind tunnel testing. |

**Reference Books:**


| | |
|---|---|
| 1. | John D Anderson Jr. Hypersonic and High Temperature Gas Dynamics, AIAA, 2000. |
| 2. | Frank K.Lu and Dart E. Marran, Advanced Hypersonic Test Facilities, AIAA 2002. |
| 3. | Cherynl C.G., Introduction to Hypersonic Flow, Academic Press,1961. |


**CO, PO Mapping**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | THEORY OF AERO ELASTICITY | Semester | II |
|---|---|---|---|
| Course Code | MVJ22MAE242 | CIE | 50 |
| Total No. of Contact Hours | **40 L: T:P: 2:0:2** | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

Course objective is to:

- Understand the deformation of structure under static and dynamic loads
- Acquire knowledge of aero elastic effects on airplane performance and maneuvers.
- Know the wind tunnel model similarities and testing of models.

| Module 1 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Aeroelastic phenomenon: flutter, buffeting, dynamic loads problems, load distribution, divergence, control effectiveness & reversal. Deformation of airplane structures under static loads: Forces acting on aeroplane, Influence coefficients. Properties of influence coefficients. Deformation under distributed forces. Simplified elastic airplane. Bending, torsional and shear stiffness curves.

Laboratory Session/Experimental Learning: Aerodynamic interaction between wing and truss in transonic flow using ANSYS Applications:

1. Structural Strength
2. Control Effectiveness
3. Moment acting on body
4. Unsteady flow flutter analysis Video links:

https://nptel.ac.in/courses/101104005/

https://youtu.be/pi5hAK0FdWA

| Module 2 | L1,L2,L3, | 08 Hrs. |
|---|---|---|

Static aeroelastic phenomena: Load distribution and divergence-wing torsional divergence (two-dimensional case, & finite wing case). Prevention of aeroelastic instabilities. Control effectiveness and reversal: Aileron effectiveness and reversal -2 dimensional case, and finite wing case. Strip theory. Aileron effectiveness in terms of wing -tip helix angle. Critical aileron reversal speed. Rate of change of local pitching moment coefficient with aileron angle.

Laboratory Session/Experimental Learning: Effect of wing sweep and thickness on drag divergence mach number

Applications:

1. Mach divergence
2. Flutter Analsys Video links:

https://nptel.ac.in/courses/101104005/

| Module 3 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Deformation of airplane structures under dynamic loads: Differential and Integral forms of equations of motions of vibrations. Natural modes and frequencies of complex airplane structures - introduction. Dynamic response phenomenon. Dynamic problems of Aeroelasticity: Determination of critical flutter speed. Aeroelastic modes. Wing bending and torsion flutter. Coupling of bending and torsion oscillations and destabilizing effects of geometric incidences. Flutter prevention and control.

Laboratory Session/Experimental Learning: Comparison of flutter speed BetweenTheodorsen, Wagner and Quasi-steady approximation for 2D Applications:

1. Selection of optimal approximation based on the condition
2. Analyze the airspeed at different location

Video links:

https://nptel.ac.in/courses/101104005/

| Module 4 | L1,L2,L3 | 08 Hrs. |
|---|---|---|

Test model similarities: Dimensional concepts. Vibration model similarity laws. Dimensionless form of equation of motion. Mode shapes and natural frequencies in dimensionless forms. Model scale factors. Flutter model similarity law. Scale factors. Structural simulation:-shape, mass and stiffness.

Laboratory Session/Experimental Learning: Study of wingtip washout using flat wing varying stiffness Applications:

1. load distribution
2. Position of Aerodynamic center
3. Design consideration to reduce wingtip stall Video links:

https://nptel.ac.in/courses/101104005/

| Module 5 | L1,L2 | 08 Hrs. |
|---|---|---|

Testing techniques: Measurement of structural flexibility, natural frequencies and mode shapes. Polar plot of the damped response. Identification and measurement of normal modes. Steady state and dynamic Aeroelastic model testing.

Laboratory Session/Experimental Learning: Calculate first 7 flexible modes in Simple aeroelastic model of a Generic transport aircraft Applications:

| |
|---|
| 1. Flutter mechanism between different modes<br>2. First mode: Wing bending<br>3. Third mode: Aileron deflection Video links:<br>https://nptel.ac.in/courses/101104005/ |

| Course outcomes:<br>Upon completion of the course, students will be able to: | |
|---|---|
| CO1 | Estimate structural deformations under static loading conditions. |
| CO2 | Estimate structural deformations under dynamic loading conditions. |
| CO3 | Analyze effect of aero elasticity on airplane performance and stability. |
| CO4 | Develop wind tunnel models for aeroelastic testing. |
| CO5 | Different testing techniques for static and dynamic Aeroelastic model. |

| Reference Books: | |
|---|---|
| 1. | Dowell, E. H., Crawley, E. F., Curtiss Jr., H. C., Peters, D. A., Scanlan, R. H., and Sisto, F., A Modern Course in Aeroelasticity, Kluwer Academic Publishers, 3rd Edition, 1995. |
| 2. | Bisplinghoff, R., Ashley, H., and Halfman, R. L., Aeroelasticity, Dover, 1955. |
| 3. | Fung, Y. C., An Introduction to the Theory of Aeroelasticity, Dover, 1969. |
| 4. | Megson THG, Aircraft structures for Engineering students, Edward Arnold. |

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 3 |
| CO2 | 3 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 2 |
| CO3 | 2 | 2 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 2 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| CO5 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| Course Title | THEORY OF COMBUSTION | Semester | II |
|---|---|---|---|
| Course Code | MVJ22MAE243 | CIE | 50 |
| Total No. of Contact Hours | 40 L: T:P: 2:0:2 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

1. Understand the concept of combustion.
2. Understand the combustion fundamentals and performance.
3. Understand the concept of combustion sustainability in gas turbines.
4. Understand the combustion noise.
5. Acquire knowledge of combustion emission.

| **Module 1** | **L1, L2** | 10 Hrs. |
|---|---|---|

**Combustion Fundamentals:** Deflagration, Detonation, Classification of Flames, Flammability Limits, Weak Mixtures, Rich Mixtures, Laminar Premixed Flames, Laminar Diffusion Flames, Turbulent Premixed Flames, Droplet and Spray Evaporation, Ignition Theory. Adiabatic Flame Temperature.

**Laboratory Sessions/ Experimental learning: Aircraft propulsion lab**

**Applications: Rockets engines, Gas turbine engines**

**Video link / Additional online information (related to module if any):**

https://nptel.ac.in/courses/101/108/101108068/

| **Module 2** | **L1, L2** | 10 Hrs. |
|---|---|---|

**Combustion Performance**: Combustion Efficiency, The Combustion Process, Reaction-Controlled Systems, Mixing-Controlled Systems, Evaporation-Controlled Systems. Flame Stabilization & Fuel Classification: Definition of Stability Performance, Measurement of Stability Performance, Bluff-Body Flame holders, Stabilization, Flame Stabilization in Combustion Chambers, Aircraft Gas Turbine Fuels, Engine Fuel System.

**Laboratory Sessions/ Experimental learning: Aircraft propulsion lab**

**Applications: Rockets engines, Gas turbine engines**

**Video link / Additional online information (related to module if any):**

2. https://nptel.ac.in/courses/101/108/101108068/

| **Module 3** | **L1, L2** | 10 Hrs. |
|---|---|---|

**Basic Considerations:** Introduction to Gas Turbine Combustor, Basic Design Features, Combustor Requirements, Combustor Types and parts, Fuel Preparation, Atomizers, liner wall-cooling Techniques,

combustor stability limits, combustor exit temperature traverse quality (pattern factors), Combustors for Low Emissions.

**Laboratory Sessions/ Experimental learning: Aircraft propulsion lab**

**Applications: Rockets engines, Gas turbine engines**

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/121/106/121106014/

| **Module 4** | **L1, L2, L3** | 10 Hrs. |
|---|---|---|

Alternate fuel and Combustion Noise: Introduction, Alternate fuels used in Aero applications, Direct Combustion Noise, Combustion Instabilities, Influence of Fuel Type, Combustor Operating Conditions, Ambient Conditions, Aerodynamic Instabilities, Control of Combustion Instabilities, Modeling of Combustion Instabilities.

**Laboratory Sessions/ Experimental learning: Aircraft propulsion lab**

**Applications: Rockets engines, Gas turbine engines**

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/108/101108068/

| **Module 5** | **L1, L2, L3** | 10Hrs. |
|---|---|---|

Combustion Emissions: Introduction, Regulations, Mechanisms of Pollutant Formation. Pollutants Reduction in Conventional Combustors, Pollutants Reduction by Control of Flame Temperature, Dry Low-Oxides of Nitrogen Combustors. Lean Premix Prevaporize Combustion, Catalytic Combustion.

**Laboratory Sessions/ Experimental learning: Aircraft propulsion lab**

**Applications: Rockets engines, Gas turbine engines**

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/108/101108068/

**Course outcomes:**

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

| | |
|---|---|
| CO312.3.1 | Apply the concept of combustion |
| CO312.3.2 | Analyse the combustion performance. |
| CO312.3.3 | Apply the concept of combustion sustainability in gas turbines |
| CO312.3.4 | Analyse the Combustion Noise |
| CO312.3.5 | Analyse the Combustion Emissions |

**Reference Books:**

| | |
|---|---|
| 1. | Arthur H. Lefebvre &Dilip R. Ballal, Gas Turbine Combustion, CRC Press, 3rd Edition,2010 |

| | |
|---|---|
| 2. | Minkoff, G.J., and C.F.H. Tipper, Chemistry of Combustion Reaction, London Butterworth, 1962. |
| 3. | Samir Sarkar**,** Fuels & Combustion, Orient Long man 1996. |
| 4. | Wilson, P.J. and J.H. Wells, Coal, Coke and Coal Chemicals, McGraw-Hill, 1960. |

| **CIE Assessment:** |
|---|
| CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests<br>- Quizzes/mini tests (4 marks)<br>- Mini Project / Case Studies (8 Marks)<br>- Activities/Experimentations related to courses (8 Marks) |
| **SEE Assessment:** |
| vii. Question paper for the SEE consists of two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.<br>viii. Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.<br>ix. One question must be set from each unit. The duration of examination is 3 hours. |

| **CO, PO Mapping** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 |
| CO4 | 3 | 3 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **Course Title** | ARTIFICIAL INTELLIGENCE AND ROBOTICS | Semester | II |
| **Course Code** | MVJ22MAE244 | **CIE** | 50 |
| **Total No. of Contact Hours** | 40 L: T:P: 2:0:2 | **SEE** | 50 |
| **No. of Contact Hours/week** | 4 | **Total** | 100 |
| **Credits** | 3 | **Exam. Duration** | 3 Hrs. |

**The course objective is to:**

1. Understand the basic techniques of artificial intelligence
2. Understand Non-monotonic reasoning and statistical reasoning
3. Introduce the electronics and software aspects in the design of robots
4. Introduce the latest state of the art robots
5. Understand the usage of AI in Robots

| **Module 1Introduction to AI** | **L1,L2,L3** | 10 Hrs. |
|---|---|---|

Computerized reasoning - Artificial Intelligence (AI) - characteristics of an AI problem - Problem representation in AI - State space representation - problem reduction-Concept of small talk programming

**Laboratory Sessions/ Experimental learning:** Compare the theoretical solution to the forward kinematics problem with a physical implementation on the robot.

**Applications:** Design, Supply chain management, Prediction of in-service damages

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/106/102/106102220/

| **Module 2Search Process Knowledge Representation** | **L1, L2, L3,** | 10 Hrs. |
|---|---|---|

**Search Process:** AI and search process - Brute force search techniques - Depth first - Breadth first search techniques - Hill climbing - Best first search - AND/OR graphs - A* algorithm - Constraint satisfaction.

**Knowledge Representation:** Logic, Propositional logic - Tautology - Contradiction - Normal forms - Predicate logic - Rules of inference - Resolution - Unification algorithm -Production rules - Semantic networks - Frames – Scripts - Conceptual dependency.

**Laboratory Sessions/ Experimental learning:** Derive and implement a solution to the inverse kinematics problem for the robot

**Applications:** Predictive Maintenance, Flight performance Optimization, Reverse Engineering

**Video link / Additional online information (related to module if any):**

**3.** https://nptel.ac.in/courses/106/102/106102220/

| **Module 3 Introduction to Robotics** | **L1, L2, L3** | 10 Hrs. |
|---|---|---|

| | | |
|---|---|---|
| **Scope of Robots:** The scope of industrial Robots - Definition of an industrial robot - Need for industrial robots.<br>**Robot Components:** Fundamentals of Robot Technology - Automation and Robotics - Robot anatomy - Work volume- Precision of movement - End effectors - Sensors<br>**Laboratory Sessions/ Experimental learning:** Controlling the robots using the programming language<br>**Applications:** Quality control, Smart Factory Building, Repetitive work management<br>**Video link / Additional online information (related to module if any):**<br>2. https://nptel.ac.in/courses/112/105/112105249/ | | |
| **Module 4Future Trends in Robots** | **L1, L2, L3** | 10 Hrs. |
| Telepresence robot - Autonomous mobile robots - Walker Robots – Solar ball Robot – Under water bots – Aerobots - Advanced robotics in Space - Specific features of space robotics systems – long term technical developments - Next generation robots.<br>**Laboratory Sessions/ Experimental learning:** Integrate computer vision and control of the robot<br>**Applications:** Training, Smart Repairs Management<br>**Video link / Additional online information (related to module if any):**<br>1. https://nptel.ac.in/courses/112/105/112105249/ | | |
| **Module 5AI in Robotics** | **L1, L2** | 10 Hrs. |
| Robotic perception, localization – mapping- configuring space - planning uncertain movements - dynamics and control of movement, Ethics and risks of artificial intelligence in robotics.<br>**Laboratory Sessions/ Experimental learning:** Integrate forward and inverse kinematics and computer vision to control the robot<br>**Applications:** AI Autopilot in commercial flights, Knowledge-Based Engineering<br>**Video link / Additional online information (related to module if any):**<br>2. https://nptel.ac.in/courses/106/102/106102220/ | | |

**Course outcomes:**

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

| | |
|---|---|
| CO313.2.1 | Apply the basic techniques of artificial intelligence |
| CO313.2.2 | Compare and contrast Non-monotonic reasoning and statistical reasoning |
| CO313.2.3 | Design and develop robotic based systems |
| CO313.2.4 | Develop automatic solution for replacing humans in life threatening area |
| CO313.2.5 | Interpret basic AI algorithms in Robotics |

Reference Books:


| | |
|---|---|
| 1. | Elaine Rich And Kevin Knight, Artificial Intelligence, Tata Mcgraw-Hill, 3rd edition,2008. |
| 2. | Barry Leatham - Jones, Elements of industrial Robotics, Pitman Publishing, 1987 |

| | |
|---|---|
| 3. | J. M. Selig, Introductory Robotics, Prentice Hall, 1992 |
| 4. | David Jefferis, Artificial Intelligence: Robotics and Machine Evolution, Crabtree Publishing Company, 1992 |


CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests

- Quizzes/mini tests (4 marks)
- Mini Project / Case Studies (8 Marks)
- Activities/Experimentations related to courses (8 Marks)

SEE Assessment:

- Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.
- Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.
- One question must be set from each unit. The duration of examination is 3 hours.

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 2 | 2 | - | - | - | - | - | - | - | - | - | - | 1 | 1 |
| CO2 | 3 | 3 | - | - | 3 | - | - | - | - | - | - | - | 1 | 1 |
| CO3 | - | - | - | - | - | 3 | - | - | - | - | - | - | 1 | 1 |
| CO4 | - | - | 3 | - | - | 2 | 3 | - | - | - | - | 3 | 1 | 1 |
| CO5 | 3 | 3 | 3 | - | 3 | - | 2 | - | - | - | - | 3 | 1 | 1 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **`Course Title** | **HELICOPTER DYNAMICS** | **Semester** | **II** |
| **Course Code** | **MVJ22MAE245** | **CIE** | **50** |
| **Total No. of Contact Hours** | **40 L: T:P: 2:0:2** | **SEE** | **50** |
| **No. of Contact Hours/week** | **4** | **Total** | **100** |
| **Credits** | **3** | **Exam. Duration** | **3 Hrs.** |

**The course objective is to:**

1. Comprehend the basic concepts of helicopter dynamics.
2. Acquire knowledge of helicopter performance and rotor bearing system.
3. Understand the Aerodynamics of Rotor Airfoil and rotor wake phenomenon
4. Gain knowledge on the stability and control of Helicopter and its flight test requirements
5. Comprehend the design of Helicopter and its standards and specifications

| **Module 1** | **L1, L2** | 10Hrs. |
|---|---|---|

**Introduction:** History of helicopter flight. Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust and power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation.

**Blade Element Analysis:** Blade element analysis in hovering and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, lead/lag hinge, and drag hinge.

**Laboratory Sessions/ Experimental learning:**

Study of Performance of Propeller

**Applications:**

Understand the fundamentals of Helicopters dynamics

**Video link / Additional online information (related to module if any):**

2. NPTEL- Introduction to Helicopter Aerodynamics & Dynamics

https://nptel.ac.in/courses/101/104/101104017/

| **Module 2** | **L1, L2** | 10Hrs. |
|---|---|---|

**Basic Helicopter Performance**: Forces acting on helicopters in forward flight. Methods of achieving translatoryflight. Controlling cyclic pitch: Swash-plate system. Lateral tilt with and without conning. Lateral and longitudinal asymmetry of lift in forward flight. Forward flight performance- total power required effects of gross weight, effect of density altitude. Speed for minimum power, and speed for maximum range. Factors affecting forward speed, and ground effects.

**Laboratory Sessions/ Experimental learning:**

Study of the Surface pressure distribution on a 2-D cambered airfoil

**Applications:**

Study the performance of helicopter and the mechanism of swash plate assembly

**Video link / Additional online information (related to module if any):**

1. NPTEL- Introduction to Helicopter Aerodynamics & Dynamics

https://nptel.ac.in/courses/101/104/101104017/

| **Module 3** | **L1, L2** | 10Hrs. |
|---|---|---|

**Rotor Airfoil Aerodynamics:** Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range.

**Rotor Wakes and Blade Tip Vortices:** Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake.

**Laboratory Sessions/ Experimental learning:**

Smoke Flow visualization studies on 2-D airfoil and Circular cylinder

Tuft Flow visualization studies on 2-D airfoil

**Applications:**

Learn the aerodynamics of helicopter rotor

**Video link / Additional online information (related to module if any):**

1. NPTEL- Introduction to Helicopter Aerodynamics & Dynamics
   https://nptel.ac.in/courses/101/104/101104017/

| **Module 4** | **L1,L2** | 10Hrs. |
|---|---|---|

**Helicopter Stability and Control.** Introductory concepts of stability.Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional and directional. Dynamic stability aspects. Main rotor and tail rotor control. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, Levels of handling qualities.

**Flight Testing**- General handing flight test requirements and, basis of limitations.

**Laboratory Sessions/ Experimental learning:**

Calculation of aerodynamic coefficients forces acting on a model aircraft using force balance at various angles of incidence

**Applications:**

Understand the stability & control aspects of helicopter and flight test requirements

**Video link / Additional online information (related to module if any):**

1. NPTEL- Introduction to Helicopter Aerodynamics & Dynamics

| | | |
|---|---|---|
| https://nptel.ac.in/courses/101/104/101104017/ | | |
| **Module 5** | **L1, L2** | 10Hrs. |

**Standards and Specifications:** Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification.

**Conceptual Design of Helicopters:** Overall design requirements. Design of main rotors-rotor diameter, tip speed, rotor solidity, blade twist and aerofoil selection, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft.

**Laboratory Sessions/ Experimental learning:**

Measurement of typical boundary layer velocity profile on the airfoil from leading edge to trailing edge

**Applications:**

Learn the design requirements of helicopter and its standards & specifications

**Video link / Additional online information (related to module if any):**

1. NPTEL- Introduction to Helicopter Aerodynamics & Dynamics

https://nptel.ac.in/courses/101/104/101104017/

**Course outcomes:**

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

| | |
|---|---|
| CO312.1.1 | Apply the basic concepts of helicopter dynamics. |
| CO312.1.2 | Evaluate the helicopter performance. |
| CO312.1.3 | Outline the Aerodynamics of rotor Airfoil and rotor wake |
| CO312.1.4 | Generalize the helicopter stability and control and its test requirements |
| CO312.1.5 | Illustrate the design of a helicopter and its standards and specifications |

Reference Books:


| | |
|---|---|
| 1. | J. Gordon Leishman, Principles of Helicopter Aerodynamics, Cambridge University Press, 2002. |
| 2. | George H. Saunders, Dynamics of Helicopter Flight, John Wiley & Sons, Inc, NY,1975. |
| 3. | W Z Stepniewski and C N Keys, Rotary Wing Aerodynamics, Dover Publications, Inc, New York, 1984. |
| 4. | ARS Bramwell, George Done, and David Balmford, Helicopter Dynamics, 2nd Edition, Butterworth-Heinemann Publication, 2001. |


CIE Assessment:

CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA

| marks to be awarded will be the average of three tests<br>- Quizzes/mini tests (4 marks)<br>- Mini Project / Case Studies (8 Marks)<br>- Activities/Experimentations related to courses (8 Marks) |
|---|
| SEE Assessment: |
| - Question paper for the SEE consists two parts i.e. Part A and Part B. Part A is compulsory and consists of objective type or short answer type questions of 1 or 2 marks each for total of 20 marks covering the whole syllabus.<br>- Part B also covers the entire syllabus consisting of five questions having choices and may contain sub-divisions, each carrying 16 marks. Students have to answer five full questions.<br>- One question must be set from each unit. The duration of examination is 3 hours. |

| CO-PO-PSO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | 1 | - | - |
| CO2 | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | 1 | - | - |
| CO3 | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | 1 | - | - |
| CO4 | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | 1 | - | - |
| CO5 | 3 | 2 | 2 | 1 | - | - | - | 1 | 1 | 1 | 1 | 1 | 3 | 3 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **Course Title** | **STRUCTURES LAB** | **Semester** | II |
| **Course Code** | MVJ22MAEL26 | **CIE** | 50 |
| **Total No. of Contact Hours** | **30 L: T:P: 1:0:2** | **SEE** | 50 |
| **No. of Contact Hours/week** | 03 | **Total** | 100 |
| **Credits** | 02 | **Exam. Duration** | 3 Hours |

**Course objective is to:**

- Learn about the simply supported beam, cantilever beam.
- understand the Maxwell's theorem and Poisson ratio.
- Acquire the knowledge about buckling load, shear failure and shear center

| Sl No | Experiment Name | RBT Level | Hours |
|---|---|---|---|
| **1** | Deflection of a Simply Supported Beam | L1,L2,L3 | 03 |
| **2** | Deflection of a Cantilever Beam | L1,L2,L3 | 03 |
| **3** | Beam with Combined Loading by using Superposition Theorem | L1,L2,L3 | 03 |
| **4** | Verification of Maxwell's Reciprocal Theorem for Beam with<br>a) Constant cross section<br>b) varying Cross section | L1,L2,L3 | 03 |
| **5** | Determination of Young's Modulus and Poisson Ratio using Strain Gages. | L1,L2,L3 | 03 |
| **6** | Buckling Load of Slender Eccentric Column sand Construction of South Well Plot | L1,L2,L3 | 03 |
| **7** | Shear Failure of Bolted and Riveted Joint | L1,L2,L3 | 03 |
| **8** | Bending Modulus of Sandwich Beam | L1,L2,L3 | 03 |
| **9** | Determine the Index Factor `K `in a Tensile Field of Wagner Beam | L1,L2,L3 | 03 |
| **10** | Tensile, Compressive and FlexuralTesting of a Composite Material Plate | L1,L2,L3 | 03 |
| **11** | Determination of Natural Frequency and Mode Shapes of a Cantilever Beam for the Following Cases<br>a) Constant cross section<br>b) Varying cross section | L1,L2,L3 | 03 |
| **12** | Determination of Shear Centre for Following Cases through Deflection<br>a) Close section–Symmetrical bending<br>b) Open section–Unsymmetrical bending | L1,L2,L3 | 03 |

| | | | |
|---|---|---|---|
| **13** | Determination of Shear flow for Following Cases<br>a) Close section–Symmetrical bending<br>b) Open section–Unsymmetrical bending | L1,L2,L3 | 03 |
| **14** | Determining of Shear Centre Through Shear Flow Measurement for Following Cases<br>a) Close section–Symmetrical bending<br>b) Open section–Unsymmetrical bending | L1,L2,L3 | 03 |
| | | | |

| **Course outcomes:** | |
|---|---|
| CO1 | Compute the deflection of simply supported beam and cantilever beam. |
| CO2 | Verify the Maxwell's theorem. |
| CO3 | Determine the buckling load, shear failure and shear center. |

| **CO-PO Mapping** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

High-3, Medium-2, Low-1

**III SEMESTER M.Tech AE**

| S. No | Course | | Course Title | Teaching Department | Teaching hours/week | | | Examination | | | | | Credits |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Theory | Practical / Seminar | Tutorial / Skill Development Activity | Self-Study Component | Duration in Hours | CIE Marks | SEE Marks | Total marks | |
| | Type | Code | | | L | T | P | S | | | | | |
| 1 | PCC | MVJ22MAE31 | Aircraft Flight Dynamics and Automatic Flight Control | AE | 3 | 0 | 2 | 0 | 3 | 50 | 50 | 100 | 4 |
| 2 | PEC | MVJ22MAE32X | Professional elective -3 | AE | 3 | 0 | 0 | 0 | 3 | 50 | 50 | 100 | 3 |
| 3 | OEC | MVJ22MAE33X | Open elective Courses-1 | AE | 3 | 0 | 0 | 0 | 3 | 50 | 50 | 100 | 3 |
| 4 | PROJ | MVJ22MAEP34 | Project Work phase -1 | AE | 0 | 6 | 0 | 0 | - | 100 | - | 100 | 3 |
| 5 | SP | MVJ22MAES35 | Societal Project | AE | 0 | 6 | 0 | 0 | - | 100 | - | 100 | 3 |
| 6 | INT | MVJ22MAEI36 | Internship | AE | (6 weeks Internship Completed during the intervening vacation of II and III semesters.) | | | | 3 | 50 | 50 | 100 | 6 |
| **Total** | | | | | **9** | **12** | **2** | **-** | **-** | **400** | **200** | **600** | **22** |

Note: PCC: Professional core courses, PEC: Professional Elective Courses, IPCC-Integrated Professional Core Courses. MPS-Mini Project with Seminar; AUD/AEC; Audit Courses / Ability Enhancement Courses (Mandatory), PCCL-Professional Core Course lab, L-Lecture, P-Practical, T/SDA-Tutorial / Skill Development Activities (Hours are for Interaction between faculty and students) PP/NP-Passed / Not Passed (Only for non-Credit Course)

| **Professional Elective -3** | | **Open Elective Courses-1** | |
|---|---|---|---|
| MVJ22MAE321 | Flight Vehicle Design | MVJ22MAE331 | Unmanned Aerial Vehicles |
| MVJ22MAE322 | Composite Materials and Fabrication Techniques | MVJ22MAE332 | Aircraft Transportation Systems |
| MVJ22MAE323 | Rockets and Missiles | MVJ22MAE333 | Aircraft Systems and Instrumentation |
| MVJ22MAE324 | Flight Testing | MVJ22MAE334 | Composite Materials and Fabrication Techniques |
| MVJ22MAE325 | Space Mechanics | MVJ22MAE335 | Avionics |

| Course Title | AIRCRAFT FLIGHT DYNAMICS AND AUTOMATIC FLIGHT CONTROL | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE31 | CIE | 50 |
| Total No. of Contact Hours | 50 L : T : P :: 3 : 1:0 | SEE | 50 |
| No. of Contact Hours/week | 5 | Total | 100 |
| Credits | 4 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

- Understand the Concept of application of control and airframe parameters
- Acquire knowledge of vehicles equations of motion
- Understand the longitudinal dynamics.
- Understand the longitudinal and lateral feedback control
- Know the feedback systems and autopilot for pitch, roll, and yaw control

| **Module 1** | **L1,L2** | 10 Hrs. |
|---|---|---|

**Review of feedback system analysis and aerodynamic fundamentals:** Mathematical models of linear open loop and closed loop systems, Transfer functions and Bode plot and root locus methods of analysis, analysis of multi-loop vehicular control systems; Definition of airframe parameters, coefficients and reference geometries, aerodynamic characteristics of plan forms and fuselage and effectiveness of control surfaces.

| **Module 2** | **L1,L2,** | 10 Hrs. |
|---|---|---|

**Vehicle equations of motion and axis systems**: Newton's Second Law and reference frames Expansion of inertial forces and moments, gravity forces and their linearization, Expansion of aerodynamic forces and moments and direct thrust forces, Complete linearized equations of motion, description of dimensional and non-dimensional stability axis derivatives.

| **Module 3** | **L1,L2** | 10 Hrs. |
|---|---|---|

**Longitudinal dynamics**: Review of simplifying assumptions and derivation of simplified longitudinal equations of motion, longitudinal controls and control input transfer functions, two degrees of freedom short period approximations and typical example transfer functions of

conventional aircraft and their responses Lateral dynamics: Simplified lateral equations of motion, lateral controls and control input transfer functions, two degrees of freedom Dutch roll approximations, typical example transfer functions of conventional aircraft and their responses

| **Module 4** | **L1,L2** | 10 Hrs. |
|---|---|---|

| | | |
|---|---|---|
| **Longitudinal and lateral feedback control**: Longitudinal Feedback Control: Feedback of pitch angle and pitch rate to the elevator, feedback of speed error to elevator, feedback of angle of attack and acceleration to elevator, feedback of altitude to the elevator.<br>**Lateral Feedback Control**: Feedback of bank angle and rolling velocity to ailerons, feedback of other quantities to ailerons, feedback of heading angle to rudder, feedback of yawing velocity to rudder, feedback of sideslip to rudder, feedback of lateral acceleration to rudder. | | |
| **Module 5** | **L1,L2** | 10Hrs. |
| **Longitudinal and lateral autopilots**: Longitudinal Autopilots: Displacement autopilot, pitch orientational control system, acceleration control system, glide slope coupler and automatic flare control, flight path stabilization, attitude reference systems, effect of nonlinearities.<br>**Lateral Autopilots**: Damping of Dutch roll, discussion on coordination techniques and methods of obtaining coordination, yaw orientational control system and other lateral autopilot configurations, automatic lateral beam guidance. | | |
| **Course outcomes:**<br>Upon completion of the course, students will be able to: | | |
| CO1 | Define a configuration for given specifications. | |
| CO2 | Model equations of motion. | |
| CO3 | Analyse the longitudinal dynamics. | |
| CO4 | Do Preliminary feedback systems and autopilot design. | |
| CO5 | Apply autopilot mode. | |

| **Reference Books:** | |
|---|---|
| 1. | Jan Roskam: Airplane flight dynamics and automatic flight controls, Part I & II, Published by Design Analysis and Research Corporation (DAR Corporation), 2003, USA. |
| 2. | D McRuer, I Ashkenas and D Graham: Aircraft Dynamics and Automatic Control, Princeton University Press, Princeton, New Jersey, 1973 |
| 3. | Blake lock J H: Automatic Control of Aircraft and Missiles, John Wiley & Sons, Inc, 1991 |

| **CO,PO Mapping** |
|---|

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |

High,3, Medium,2, Low,1

| Course Title | FLIGHT VEHICLE DESIGN | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE321 | CIE | 50 |
| Total No. of Contact Hours | 40 L : T : P :: 3 : 1:0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

1. Understand the overview of Aircraft design process
2. Acquire knowledge of configuration layout and design of structural components
3. Gain knowledge of engine selection.
4. Comprehend the stability and control and sizing of control surfaces.
5. Understand the design aspects of subsystems

| **Module 1** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Overview of Design Process**

Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation, Thrust to Weight Ratio & Wing Loading: Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.

**Laboratory Sessions/ Experimental learning:**Design and modelling of the aircraft components based on the requirements chosen in CAAd lab

**Applications:** Apply the design requirements for an aircraft in response to requirements based on fundamental principles and statistical data in the initial phase of design.

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/106/101106035/
2. https://nptel.ac.in/courses/101/106/101106035**/**

| **Module 2** | **L1,L2,** | 8 Hrs. |
|---|---|---|

**Configuration Layout & loft**

Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Delectability. Crew station, Passenger, and Payload arrangements. Design of Structural Components: Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal & Vertical Tail Sizing. Tail

Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.

**Laboratory Sessions/ Experimental learning:**Structural analysis and Aerodynamic analysis in Ansys lab

**Applications:** Analyse the various constraints coming from specifications and choose key parameters (total weight, wing plan form, thrust/power required etc.)

**Video link / Additional online information (related to module if any):**

1.https://nptel.ac.in/courses/101/106/101106035/

2.https://nptel.ac.in/courses/101/106/101106035/

3.https://nptel.ac.in/courses/101/106/101106035/#

| **Module 3** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Engine Selection & Flight Vehicle Performance**

Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices: - Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking. Enhanced lift design -Passive & Active

**Laboratory Sessions/ Experimental learning:**Modelling of engine selected in CAAD lab

**Applications:**Compare different engine configurations and choose the design which meets the requirements.

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101101002/

| **Module 4** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Static Stability & Control:** Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability- Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.

**Laboratory Sessions/ Experimental learning:**Performance analysis in Matlab

**Applications:** Calculate and compare performance and stability characteristics against design goals and generate a layout

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101104062/
2. https://nptel.ac.in/courses/101104062/#

| **Module 5** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Design Aspects of Subsystems:** Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurization and Air Conditioning System, Electrical & Avionic Systems, Structural

| |
|---|
| loads, Safety constraints, Material selection criteria. Applications:Calculate and compare performance and stability characteristics against design goals and generate a layout<br>**Laboratory Sessions/ Experimental learning:**Assemble the CAD models of the components and verify performance using CFD tool in Ansys lab.<br>**Applications:** Analyse design issues for aerodynamics, propulsion, structure, weights, stability, cost, and performance and generate a layout.<br><br>**Video link / Additional online information (related to module if any):**<br>https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101108047/lec29.pdf |

**Course outcomes:**

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

| | |
|---|---|
| CO1 | Define a configuration for given specifications. |
| CO2 | Evaluate configuration layout & airframe components sizing |
| CO3. | Determine Engine selection and flight performance |
| CO4 | Evaluate the stability and control and sizing of control surfaces. |
| CO5 | Analyse the design aspects of subsystems |

**Reference Books:**


| | |
|---|---|
| 1. | Daniel P. Raymer, Aircraft Design -A Conceptual Approach, AIAA, education Series, IVth Edition, 2006 |
| 2. | Thomas C Corke , Design of Aircraft, Pearson Edition. Inc, 2003 |
| 3. | J Roskam , Airplane Design -VOL 1 to 9 |
| 4. | John Fielding , Introduction to Aircraft Design, Cambridge University Press, 2009 |


**CO,PO Mapping**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |

High,3, Medium,2, Low,1

| Course Title | COMPOSITE MATERIALS AND FABRICATION TECHNIQUES | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE322 | CIE | 50 |
| Total No. of Contact Hours | 40 L : T : P :: 3 : 1:0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

- Understand the basic characteristics of composite materials
- Understand the advanced processing and fabrication techniques
- Acquire the knowledge of on micro-and macro-mechanical behavior of composite laminate
- Acquire the knowledge composite materials.
- Acquire the knowledge of MMCs and application of MMCs

| **Module 1** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Introduction to Composite Materials**

Definition, classification and characteristics of composite materials - fibrous composites, laminated. Matrix materials

**Fiber Reinforced Plastic Processing** Layup and curing, fabricating process - open and closed mould process - hand layup techniques structural laminate bag molding, production procedures for bag molding

**Metal Matrix Composites**: Introduction, Reinforcement materials, role of metal matrix, types, characteristics and selection of base metals. Advantage, disadvantage and Application of MMCs.

**Laboratory Sessions/ Experimental learning Optional**

**Applications Composites are latest application in Aeronautical and Aerospace**

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/112104229

| **Module 2** | **L1,L2,L3,** | 8 Hrs. |
|---|---|---|

**Advanced Processing Techniques and Application of Composites** Filament winding, pultrusion, pulforming, thermo - forming, injection, injection molding, liquid molding, blow molding, Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.

**Laboratory Sessions/ Experimental learning: Optional** Applications: Manufacturing of aircraft structural components

**Video link / Additional online information**:

https://nptel.ac.in/courses/112104221/

| Module 3 | L1,L2,L3 | 8 Hrs. |
|---|---|---|
| **Micro-Mechanical Behavior of a Lamina**<br>Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants.<br>**Ultimate Strengths of a Unidirectional Lamina**<br>**Macro-Mechanical Behaviour of a Laminate:**<br>Hooke's law for different types of materials, Number of elastic constants, Two - dimensional relationship of compliance and stiffness matrix. Global and local axis for angle lamina, Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.<br>**Laboratory Sessions/ Experimental learning:**<br>Determination of Young's Modulus of a Composite beam<br>**Applications:**Basics of macro level elastic properties, Scales of analysis of composites. Unidirectional and Woven fibers<br>**Video link / Additional online information (related to module if any):**<br>https://youtu.be/loyeZN5UQT8 - IIT Madras | | |
| **Module 4** | **L1,L2,L3** | 8 Hrs. |
| **Applications and Future of Composites**<br>Application developments – Aircrafts, missiles, space hardware, automobile, electrical and electronics, marine, recreational and sports equipment-future potential of composites.<br>**Future of Composites: -**General introduction and theory of nanocomposites- History of nanocomposites; Size and shape dependent properties and their uniqueness. Flexible Composites, High Temperature materials.<br>**Laboratory Sessions/ Experimental learning:**<br>**1. Evaluate the mechanical properties of a lamina and a laminate**<br>**Applications:** Specific Aircraft Structural components.<br>**Video link / Additional online information (related to module if any):**<br>**https://www.youtube.com/embed/PzdCymgyZ6c** - IIT Kanpur | | |
| **Module 5** | **L1,L2** | 8 Hrs. |
| **Composite Testing, Inspection & Quality Control**: Determination of Mechanical properties of composite materials, Testing of composites – Interlaminar Shear testing, Fracture testing, Delamination, Raw material testing. Destructive & Non-Destructive Testing, Tensile, Compression, Flexural, Shear, Hardness; ultrasonic testing – A-B-C scan<br>**Laboratory Sessions/ Experimental learning:**<br>**1.** Determination of Defects in a composite by NDT Methods<br>**Applications: NDT- DT Methods, Composites in Aerospace sector** | | |

| **Video link / Additional online information (related to module if any):** | |
|---|---|
| 1. https://youtu.be/ZMJ7O4vs-Q8 - IIT Kanpur | |
| **Course outcomes:** Upon completion of the course, students will be able to: | |
| CO1 | Compare the properties and select material for the given application. |
| CO2 | Fabricate composite parts |
| CO3 | Apply constitutive equations of *composite* materials and understand mechanical behaviour at *micro and macro* levels. |
| CO4 | Apply the composite materials for a specific application |
| CO5 | Carry out various inspections in accordance with the established procedures and differentiate various defect types and select the appropriate **NDT** methods for better evaluation |

| **Reference Books:** | |
|---|---|
| 1. | K.K Chawla, Composite Materials- Science and Engineering, IV edition, Springer International Publishing, 2019: ISBN: 978-3-030-28983-6 |
| 2. | Autar Kaw, Mechanics of Composites, II edition, Taylor & Francis Group CRC Press. 2006, ISBN:978-0-8493-1343-1 |
| 3. | R M Jones,Mechanics of Composite Materials, 2nd Edition, Taylor & Francis, 2015; ISBN:978-1560327127 |
| 4. | Ajay Kapadia**,** Non-Destructive Testing of Composite Materials, National Composites Network, Best Practices Guide, TWI Publications, 2006. |

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| CO2 | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |

High,3, Medium,2, Low,1

| Course Title | ROCKETS AND MISSILES | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE323 | CIE | 50 |
| Total No. of Contact Hours | 40 L: T : P :: 3 :1 : 0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**Course objective is to:**

This course will enable students to

1. Understand the types of Space Launch vehicles and Missiles.
2. Study the components and working solid rocket motors
3. Acquire knowledge of components and working of liquid rocket motors
4. Understand Trajectory monitoring and control.
5. Acquire the knowledge on rocket materials and testing.

| Module 1 | L1,L2,L3 | 8 Hrs. |
|---|---|---|

**Introduction:** Space launch Vehicles and military missiles, function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements, performance measures, design, construction, operation, similarities, and differences. Some famous space launch vehicles and strategic missiles.

**Launch Vehicle Dynamics:** Tsiolskovsky's rocket equation, range in the absence of gravity, vertical motion in the earth's gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, multi staging.

**Laboratory Sessions/ Experimental learning:**

Calculate the ballistic missile trajectories.

**Applications:**

Designing missiles, rockets, spacecrafts, launching of satellites.

**Video link / Additional online information (related to module if any):**

2. https://nptel.ac.in/courses/101/104/101104078/
3. https://www.youtube.com/watch?v=cTq5UaAxp2I
4. https://design.mst.edu/designteams/rocket-design/

| Module 2 | L1,L2,L3, | 8 Hrs. |
|---|---|---|

**Solid Propellant Rocket Motor Systems:** Solid Propellant rocket motors, principal features, applications. Solid propellants, types, composition, properties, performance. Propellant grain, desirable properties, grain configuration, preparation, loading, structural design of grain. Liners, insulators and inhibitors, function,

requirements, materials. Rocket motor casing – materials. Nozzles, types, design, construction, thermal protection. Igniters, types, construction. Description of modern solid boosters I) Space Shuttle SRB, II) the Arienne SRB

**Laboratory Sessions/ Experimental learning:**

To calculate thrust profile for different solid grain structures.

**Applications:**

Selection of solid propellant based on the mission requirement, grain configuration and resulting different thrust profile, design important systems of rockets and missiles.

**Video link / Additional online information (related to module if any):**

1. https://www.youtube.com/watch?v=irpJBnu5Y2I
2. https://www.youtube.com/watch?v=6B-8l-mWTUU
3. https://www.grc.nasa.gov/www/k-12/rocket/rktengine.html

| Module 3 | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

Liquid Propellant Rocket Engine Systems: Liquid propellants, types, composition, properties, performance. Propellant tanks, feed systems, pressurization, turbo-pumps, valves and feed lines, injectors, starting and ignition. Engine cooling, support structure. Control of engine starting and thrust build up, system calibration, integration, and optimisation – safety and environmental concerns. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines.

Laboratory Sessions/ Experimental learning:

To study the burning velocity of premixed flames at various air/fuel ratio.

Applications:

Selection of liquid propellant based on the mission requirement, specific impulse resulting from different fuel and oxidizer combination, design of pump or pressure feed system for propellant transfer from tanks to combustion chamber.

Video link / Additional online information (related to module if any):

https://www.youtube.com/watch?v=atdkmxC75Cs

https://www.youtube.com/watch?v=yt6nnz-kuaU

https://www.hq.nasa.gov/pao/History/SP-4209/ch3-4.htm

| **Module 4** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Attitude Control of Rockets and Missiles:** Rocket Thrust Vector Control – Methods of Thrusts Vector Control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.

**Trajectory Monitoring and control:**Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments, lateral aerodynamic moment, lateral damping moment,

longitudinal moment of a rocket, Rocket Dispersion. Missile Autopilot, proportional navigation guidance, command guidance.

**Laboratory Sessions/ Experimental learning:**

Role of multi staging in performance of launch vehicles.

**Applications:**

Planning and designing of flight path and trajectories for rockets and missiles. Directional change control using thrust vectoring.

**Video link / Additional online information (related to module if any):**

1. https://www.youtube.com/watch?v=L0SbCVyLNP8
2. https://www.youtube.com/watch?v=L0SbCVyLNP8
3. https://bps.space/tvc

| **Module 5** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Rocket Testing:** Ground Testing and Flight Testing, Types of Tests facilities and safeguards, monitoring and control of toxic materials, instrumentation, and data management. Ground Testing, Flight Testing, Trajectory monitoring, post -accident procedures. Descriptions of a typical space launch vehicle launch procedure.

**Materials:** Criteria for selection of materials for rockets and missiles, requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, re-entry body design consideration, requirements of materials for thermal protection and for pressure vessels.

**Laboratory Sessions/ Experimental learning:**

Reentry vehicles: Sphere v/s Blunt bodies drag estimation.

**Applications:**

Selection of right materials depending on the mission requirement. Designing of a failsafe testing rocket system. Design of Rockets and Missiles, aerodynamic controls, reentry body design configurations.

**Video link / Additional online information (related to module if any):**

2. https://nptel.ac.in/courses/101/104/101104078/
3. https://nptel.ac.in/content/storage2/101/104/101104078/MP4/mod11lec53.mp4
4. https://www.sciencebuddies.org/science-fair-projects/project-ideas/Phys_p008/physics/model-rocket-propulsion#background

**Course outcomes:**

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

| | |
|---|---|
| CO313.3.1 | Apply knowledge gained in identifying the types of space launch vehicles and missiles. |
| CO313.3.2 | Evaluate solid propellant motors. |
| CO313.3.3 | Analyse liquid propellant engines. |
| CO313.3.4 | Predict the trajectory of rocket and estimate error in dispersion. |

| | |
|---|---|
| CO313.3.5 | Select material for application and analyse rocket testing. |

| Reference Books: | |
|---|---|
| 1. | George P Sutton and Oscar Biblarz, Rocket Propulsion Element, John Wiley and Sons Inc, 7th edition, 2010. |
| 2. | Cornelisse, J.W., Schoyer, Rocket Propulsion and Space Flight Dynamics, H.F.R. and Wakker,. K.F, Pitman, 1979. |
| 3. | Ball, K.J., Osborne, G.F, Space Vehicle Dynamics, Oxford University Press, 1967 |
| 4. | Parker, E.R, Materials for Missiles and Spacecraft, McGraw Hill, 1982. |

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO2 | 3 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO3 | 3 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO4 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO5 | 3 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **Course Title** | **FLIGHT TESTING** | **Semester** | **III** |
| **Course Code** | **MVJ22MAE324** | **CIE** | **50** |
| **Total No. of Contact Hours** | **40 L : T : P :: 3 : 1:0** | **SEE** | **50** |
| **No. of Contact Hours/week** | **4** | **Total** | **100** |
| **Credits** | **3** | **Exam. Duration** | **3 Hrs.** |

**The course objective is to:**

- Comprehend the basic concepts of flight test instrumentation.
- Acquire the knowledge of performance flight testing.
- Acquire the knowledge of longitudinal stability and control.
- Understand the directional and lateral stability and control.
- Understand the flying qualities.

| **Module 1** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Introduction:**

Sequence, Planning and governing regulations of flight testing. Aircraft weight and center of gravity, flight testing tolerances. Method of reducing data uncertainty in flight test data -sources and magnitudes of error, avoiding and minimizing errors.

**Flight test instrumentation:**

Planning flight test instrumentation, Measurement of flight parameters. Onboard and ground based data acquisition system. Radio telemetry.

| **Module 2** | **L1,L2,** | 8 Hrs. |
|---|---|---|

**Performance flight testing - range, endurance and climb**: Airspeed – in flight calibration. Level flight performance for propeller driven aircraft and for Jet aircraft - Techniques and data reduction. Estimation of range, endurance and climb performance.

**Performance flight testing -take-off, landing, turning flight**: Maneuvering performance estimation. Take-off and landing -methods, procedures and data reduction.

| **Module 3** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Stability and control - longitudinal and maneuvering**

Static & dynamic longitudinal stability: - methods of flight testing and data reduction techniques. Stick free stability methods. Maneuvering stability methods & data reduction.

| **Module 4** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Stability and control - lateral and directional**

| | | |
|---|---|---|
| Lateral and directional static & dynamic stability: - Coupling between rolling and yawing moments. Steady heading slide slip. Definition of Roll stability. Adverse yaw effects. Aileron reversal. Regulations, test techniques and method of data reduction. | | |
| **Module 5** | **L1,L2** | 8 Hrs. |
| **Flying qualities**: MIL and FAR regulations. Cooper-Harper scale. Pilot Rating. Flight test procedures. Hazardous flight testing: Stall and spin- regulations, test and recovery techniques. Test techniques for flutter, vibration and buffeting. | | |

| **Course outcomes:** | |
|---|---|
| Upon completion of the course, students will be able to: | |
| CO1 | Measure the flight parameters. |
| CO2 | Estimate the performance of flight. |
| CO3 | Calculate the longitudinal stability and control parameters |
| CO4 | Test the lateral and directional stability and control |
| CO5 | Apply the FAR regulations. |

| **Reference Books:** | |
|---|---|
| 1. | Ralph D Kimberlin, Flight Testing of Fixed Wing Aircraft, AIAA educational Series 2003. |
| 2. | Benson Hamlin, Flight Testing- Conventional and Jet Propelled Airplanes, Mac Millan, 1946. |
| 3. | A. Filippone, Flight Performance of Fixed and Rotary Wing Aircraft, AIAA Series, 2006 |

**CO,PO Mapping**

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |

High,3, Medium,2, Low,1

| Course Title | SPACE MECHANICS | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE325 | CIE | 50 |
| Total No. of Contact Hours | 40 L : T : P :: 3 : 1:0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

- Acquire the knowledge of space environment.
- Understand the basic concepts of space mechanics and the general N-body.
- Study satellite injection and satellite orbit perturbations.
- Acquire the knowledge of interplanetary trajectory.
- Acquire the knowledge of and ballistic missile trajectory.

| **Module 1** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Space Environment:** Peculiarities of space environment and its description, effect of space environment on materials of spacecraft structure and astronauts, manned space missions, effect on satellite life time.

| **Module 2** | **L1,L2,** | 8 Hrs. |
|---|---|---|

**Basic Concepts and the General N-Body**: The solar system, reference frames and coordinate systems, terminology related to the celestial sphere and its associated concepts, Kepler's laws of planetary motion and proof of the laws, Newton's universal law of gravitation, the many body problem, Lagrange- Jacobi identity, the circular restricted three body problem, libration points, the general N-body problem, two body problem, relations between position and time.

| **Module 3** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Satellite Injection and Satellite Perturbations**: General aspects of satellite injection, satellite orbit transfer, various cases, orbit deviations due to injection errors, special and general perturbations, Cowell's method and Encke's method, method of variations of orbital elements, general perturbations approach.

| **Module 4** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Interplanetary Trajectories**: Two-dimensional interplanetary trajectories, fast interplanetary trajectories, three dimensional interplanetary trajectories, launch of interplanetary spacecraft, trajectory estimation about the target planet, concept of sphere of influence, Lambert's theorem.

| **Module 5** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Ballistic Missile Trajectories**: Introduction to ballistic missile trajectories, boost phase, the ballistic phase, trajectory geometry, optimal flights , time of flight, re-entry phase, the position of impact point, influence coefficients.

**Course outcomes:**

| Upon completion of the course, students will be able to: | |
|---|---|
| CO1 | Predict the space environment. |
| CO2 | Apply the basic concepts of space mechanics and the general N-body. |
| CO3 | Explain satellite injection and satellite orbit perturbations. |
| CO4 | Obtain interplanetary trajectories. |
| CO5 | Analyse ballistic missile trajectories. |

| **Reference Books:** | |
|---|---|
| 1. | Cornelisse, J.W., Rocket Propulsion and Space Dynamics, W.H. Freeman&co,1984. |
| 2. | Thomson, Introduction to Space Dynamics, Dover Publications, Revised edition, 2012. |
| 3. | Vande Kamp, P., Elements of Astromechanics, Pitman,1979 |
| 4 | Willian E. Wiesel, Space Flight Dynamics, Create Space Independent Publishing Platform, 3rd Edition, 2010. |

| **CO,PO Mapping** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |

High,3, Medium,2, Low,1

| Course Title | UNMANNED AERIAL VEHICLES | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE331 | CIE | 50 |
| Total No. of Contact Hours | 40 L : T : P :: 3 :1 : 0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

1. Comprehend the basic aviation history and UAV systems
2. Understand the air vehicle basic aerodynamics and performance
3. Acquire knowledge ofStability and Control
4. Understand concepts of Propulsion, Loads and Structures
5. Comprehend the various Mission Planning and Control

| **Module 1** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

Introduction to Aviation, Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology UAVs, UAV fundamentals, Examples of UAV systems-very small, Small UAV, Medium UAV, Large UAV, UAV applications.

**Laboratory Sessions/ Experimental learning:**

Design and development of Unmanned Aerial vehicle for real world applications.

**Applications:**

Usage of UAV systems for Aerial monitoring, surveillance systems

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2. NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 2** | **L1,L2,L3,** | 8 Hrs. |
|---|---|---|

**Introduction**: The Air Vehicle Basic Aerodynamics, Basic Aerodynamics equations, Aircraft polar, The real wing and Airplane, Induced drag, The boundary layer, Flapping wings, Total Air-Vehicle Drag, Performance: Overview,Climbing flight, Range for propeller driven aircraft,Range- a jet-driven aircraft, Endurance-for propeller driven aircraft,Guiding Flight.

**Laboratory Sessions/ Experimental learning:**

Conduct the various experiments using the Aerodyanamics lab and its equations.

**Applications:**

Determine the endurance limit for propeller driven shaft.

**Video link / Additional online information (related to module if any):**

1. NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2. NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 3** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Stability & Control**: Stability, Longitudinal, lateral, Dynamic stability, Aerodynamics control, Pitch control, lateral control, Autopilots, sensor, Controller, actuator, Airframe control, Inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot.

**Laboratory Sessions/ Experimental learning:**

Determine the longitudinal, lateral and dynamic stability using the Aerodynamics control.

**Applications:**

Various sensors used for the Autopilot system and control systems.

**Video link / Additional online information (related to module if any):**

1.NPTEL- https://nptel.ac.in/courses/101/104/101104073/

2.NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 4** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Propulsion Overview:** Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine,Electric Motors, Sources of Electrical Power.

**Structures**: Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials Resin Materials, CoreMaterials& Construction Techniques.

**Laboratory Sessions/ Experimental learning:**

Determine the efficiency of the various types engines used in the Unmanned Aerial Vehicle

**Applications:**

Usage of various applications of the resin material and skin reinforcing materials for the aircraft constructions.

**Video link / Additional online information (related to module if any):**

**1.**NPTEL- https://nptel.ac.in/courses/101/104/101104073/

**2.**NPTEL- https://nptel.ac.in/courses/101/104/101104083/

| **Module 5** | **L1,L2** | 8 Hrs. |
|---|---|---|

Mission Planning and Control, Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch, Recovery Trade-offs.

**Laboratory Sessions/ Experimental learning:**

Determine the various payloads used for the various operations of flight

**Applications:**

Usage of launch and recovery systems used in the Unmanned Aerial Vehicle

| **Video link / Additional online information (related to module if any):** |
|---|
| 1.NPTEL- https://nptel.ac.in/courses/101/104/101104073/ |
| 2.NPTEL- https://nptel.ac.in/courses/101/104/101104083/ |
| **Course outcomes:** |
| Upon completion of the course, students will be able to: |

| | |
|---|---|
| CO312.3.1 | Apply the basic concepts of UAV systems |
| CO312.3.2 | Utilise the knowledge of air vehicle basic aerodynamics and performance |
| CO312.3.3 | Apply the knowledge of Stability and Control |
| CO312.3.4 | Evaluate the Propulsion systems, Loads and Structures |
| CO312.3.5 | Apply the mission, planning and control |

| Reference Books: | |
|---|---|
| 1. | Paul GerinFahlstrom , Thomas James Gleason, INTRODUCTION TO UAV SYSTEMS, 4th Edition, Wiley Publication, 2012 John Wiley & Sons, Ltd |
| 2. | Landen Rosen, Unmanned Aerial Vehicle, Publisher: Alpha Editions, ISBN 13 : 9789385505034. |
| 3. | Unmanned Aerial Vehicles: DOD‟s Acquisition Efforts, Publisher : Alpha Editions, ISBN13 : 9781297017544 |

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

High,3, Medium,2, Low

| **Course Title** | **AIRCRAFT TRANSPORTATION SYSTEMS** | **Semester** | **III** |
|---|---|---|---|
| **Course Code** | **MVJ22MAE332** | **CIE** | **50** |

| | | | |
|---|---|---|---|
| **Total No. of Contact Hours** | **40 L : T : P :: 3 : 1:0** | **SEE** | **50** |
| **No. of Contact Hours/week** | **5** | **Total** | **100** |
| **Credits** | **3** | **Exam. Duration** | **3 Hrs.** |

**The course objective is to:**

- Understand the air transport systems.
- Understand the aircraft characteristics and manufacturers.
- Acquire the knowledge of airlines and airport infrastructure.
- Understand the navigation and environmental systems.
- Acquire the knowledge of airline managerial skill

| **Module 1** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Air Transport Systems –Introduction**

Environment, transport and mobility. Systematic description and current challenges. Development of aircraft design driver-speed and range. Development of Airport, Airlines, ICAO, Regulatory Frame work and Market Aspects.

| **Module 2** | **L1,L2,** | 8 Hrs. |
|---|---|---|

**Aircraft Characteristics and Manufacturers**

Classification of flight vehicles, cabin design, basics of flight physics- structures, mass and balance. Flight performance and mission. Aircraft manufacturers, development process, production process, supply chain.

| **Module 3** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Airlines, Airport and Infrastructure**

Airline types, Network management. Flight strategy and aircraft selection, flight operations, MRO. Role of Airport, Regulatory Issues, Airport operation and services. Airport planning - infrastructure.

| **Module 4** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Air Navigation System & Environmental Systems**

Principle of operation- Role of Air Navigation services. Air space structures, Airspace and Airport capacity, Aircraft separation. Flight guidance system. Communication system. Integrated air traffic management and working system. Environmental aspects-emission, noise, and sound.

| **Module 5** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Managerial Aspects of Airlines**

Airline passenger marketing, forecasting methods, pricing and demand. Air cargo-market for air freight. Principles of airline scheduling. Fleet planning.

**Course outcomes:**

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

| | |
|---|---|
| CO1 | Explain the air transport systems. |

| | |
|---|---|
| CO2 | Describe the aircraft characteristics, airlines and airport operation. |
| CO3 | Identify the airlines and airport infrastructure |
| CO4 | Apply the Air Navigation System & Environmental Systems. |
| CO5 | Apply managerial aspects of Airlines |

| **Reference Books:** | |
|---|---|
| 1. | Dieter Shmitt, and ValkerGollnick, Air Transport System, Springer, 2016 |
| 2. | Jhon G Wensveen, Air Transportation-A Management Prospective, Ashgate Publishing Ltd, 2011 |
| 3. | Mike Hirst, The Air Transportation System, Woodhead Publishing Ltd, England, 2008 |

| **CO,PO Mapping** | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO2 | 3 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |
| CO5 | 3 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **Course Title** | **AIRCRAFT SYSTEMS AND INSTRUMENTATION** | **Semester** | **III** |
| **Course Code** | **MVJ22MAE333** | **CIE** | **50** |
| **Total No. of Contact Hours** | **40 L : T : P :: 3 :1 : 0** | **SEE** | **50** |
| **No. of Contact Hours/week** | **4** | **Total** | **100** |
| **Credits** | **3** | **Exam. Duration** | **3 Hrs.** |

**Course objective is to:**

1. Gain knowledge of the aircraft control systems.
2. Understand the applications of hydraulics and pneumatics in aircraft systems.
3. Acquire knowledge regarding aircraft engine systems.
4. Comprehend the aircraft auxiliary systems
5. Acquire the knowledge of aircraft instruments.

| **Module 1** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Airplane Control Systems:** Conventional Systems, fully powered flight controls, Power actuated systems, Modern control systems, Digital fly by wire systems, Auto pilot system active control Technology.

**LaboratorySessions/ Experimental learning:**

How it works, flight controls PID controls.

**Applications:**

Pilot training, UAV design and piloting, RC aircraft design and piloting.

**Video link / Additional online information (related to module if any):**

5. https://nptel.ac.in/courses/101/104/101104066
6. https://onlinecourses.nptel.ac.in/noc21_ae05/preview
7. https://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1067&context=aerosp

| **Module 2** | **L1,L2,L3,** | 8 Hrs. |
|---|---|---|

**Aircraft Systems:** Hydraulic systems, Study of typical workable system, components, Pneumatic systems, Advantages, Working principles, Typical Air pressure system, Brake system, Typical Pneumatic power system, Components, Landing Gear systems, Classification.

**Laboratory Sessions/ Experimental learning:**

Calculation on force required for hydraulic system and pneumatic system in aircraft applications.

**Applications:**

Hydraulic lifts, pneumatic door openings and closing, landing gears, breaks.

**Video link / Additional online information (related to module if any):**

4. https://nptel.ac.in/courses/112/105/112105047/
5. https://nptel.ac.in/courses/112/103/112103249/
6. https://sciencing.com/make-simple-hydraulic-system-7380816.html

| **Module 3** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Engine Systems:** Fuel systems for Piston and jet engines, Components of multi engines. lubricating systems for piston and jet engines - Starting and Ignition systems - Typical examples for piston and jet engines.

**Laboratory Sessions/ Experimental learning:**

Engine Fuel and Fuel Metering Systems (Lab session IIT Kanpur, Virtual lab)

https://www.youtube.com/watch?v=xEssM_sYtd8

**Applications:**

Range and Endurance calculation, actions to take in case of engine failures.

**Video link / Additional online information (related to module if any):**

1. https://nptel.ac.in/courses/101/101/101101002/
2. https://spocathon.page/video/lecture-06-lubrication-system

| **Module 4** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Auxiliary System:** Basic Air cycle systems, Vapour Cycle systems, Evaporative vapour cycle systems, Evaporative air cycle systems, Fire protection systems, Deicing and anti-icing systems.

**Laboratory Sessions/ Experimental learning:**

Response time and operations of firefighting systems in case of engine failure.

**Applications:**

Firefighting, precautions, how to fight different classes of fire.

**Video link / Additional online information (related to module if any):**

4. https://nptel.ac.in/content/storage2/courses/101106035/001_Chapter%201_L1_(01-10-2013)
5. https://nptel.ac.in/courses/103/107/103107156/
6. https://www.draeger.com/en_seeur/ Products/Aircraft-fire-training-systems.

| **Module 5** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Aircraft Instruments:** Flight Instruments and Navigation Instruments, Gyroscope, Accelerometers, Air speed Indicators, TAS, EAS, Mach Meters, Altimeters, Principles and operation, Study of various types of engine instruments, Tachometers, Temperature gauges, Pressure gauges, Operation and Principles.

**Laboratory Sessions/ Experimental learning:**

Gyroscope working and applications, Avionics lab instruments working.

**Applications:**

Understanding readings of the flight instruments, prediction of failure or trouble before actual encounter and taking necessary precautions.

| **Video link / Additional online information (related to module if any):** |
|---|
| 5. https://nptel.ac.in/courses/101/108/101108056/<br>6. https://onlinecourses.nptel.ac.in/noc20_ae01/preview<br>7. https://www.wingbug.com/wingbug-for-experimental-aircraft/ |

| **Course outcomes:** | |
|---|---|
| Upon completion of the course, students will be able to: | |
| CO1 | Distinguish the conventional and modern control systems. |
| CO2 | Analyse the aircraft systems. |
| CO3 | Analyse the working of Aircraft engine systems. |
| CO4 | Describe aircraft Auxiliary systems |
| CO5 | Applydifferent aircraft instruments. |

| **Reference Books**: | |
|---|---|
| 1. | Ian Moirand Allan Seabridge, Aircraft Systems: Mechanical, Electrical and Avionics-Subsystem Integration, Wiley India Pvt Ltd, 3rd edition, 2012. |
| 2. | Lalit Gupta and OP. Sharma, Aircraft Systems (Fundamentals of Flight Vol. IV), Himalayan Books, 2006. |
| 3. | William A Neese, Aircraft Hydraulic Systems, Himalayan Books, 2007 |
| 4. | SR. Majumdar, Pneumatic Systems, Tata McGraw Hill Publishing Co, 1st Edition, 2001 |

| CO, PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO3 | 3 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO4 | 3 | 2 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| CO5 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |

High,3, Medium,2, Low,1

| Course Title | COMPOSITE MATERIALS AND FABRICATION TECHNIQUES | Semester | III |
|---|---|---|---|
| Course Code | MVJ22MAE334 | CIE | 50 |
| Total No. of Contact Hours | 40 L : T : P :: 3 : 1:0 | SEE | 50 |
| No. of Contact Hours/week | 4 | Total | 100 |
| Credits | 3 | Exam. Duration | 3 Hrs. |

**The course objective is to:**

- Understand the basic characteristics of composite materials
- Understand the advanced processing and fabrication techniques
- Acquire the knowledge of on micro-and macro-mechanical behavior of composite laminate
- Acquire the knowledge composite materials.
- Acquire the knowledge of MMCs and application of MMCs

| **Module 1** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Introduction to Composite Materials**

Definition, classification and characteristics of composite materials - fibrous composites, laminated. Matrix materials

**Fiber Reinforced Plastic Processing** Layup and curing, fabricating process - open and closed mould process - hand layup techniques structural laminate bag molding, production procedures for bag molding

**Metal Matrix Composites**: Introduction, Reinforcement materials, role of metal matrix, types, characteristics and selection of base metals. Advantage, disadvantage and Application of MMCs.

**Laboratory Sessions/ Experimental learning Optional**

**Applications Composites are latest application in Aeronautical and Aerospace**

**Video link / Additional online information (related to module if any):**

8. https://nptel.ac.in/courses/112104229

| **Module 2** | **L1,L2,L3,** | 8 Hrs. |
|---|---|---|

**Advanced Processing Techniques and Application of Composites** Filament winding, pultrusion, pulforming, thermo - forming, injection, injection molding, liquid molding, blow molding, Automobile, Aircrafts, missiles, Space hardware, Electrical and electronics, marine, recreational and Sports equipment, future potential of composites.

**Laboratory Sessions/ Experimental learning: Optional** Applications: Manufacturing of aircraft structural components

**Video link / Additional online information**:

https://nptel.ac.in/courses/112104221/

| Module 3 | L1,L2,L3 | 8 Hrs. |
|---|---|---|

**Micro-Mechanical Behavior of a Lamina**

Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants.

**Ultimate Strengths of a Unidirectional Lamina**

**Macro-Mechanical Behaviour of a Laminate:**

Hooke's law for different types of materials, Number of elastic constants, Two - dimensional relationship of compliance and stiffness matrix. Global and local axis for angle lamina, Stress-Strain relations for lamina of arbitrary orientation, Numerical problems.

**Laboratory Sessions/ Experimental learning:**

Determination of Young's Modulus of a Composite beam

**Applications:**Basics of macro level elastic properties, Scales of analysis of composites. Unidirectional and Woven fibers

**Video link / Additional online information (related to module if any):**

https://youtu.be/loyeZN5UQT8 - IIT Madras

| Module 4 | L1,L2,L3 | 8 Hrs. |
|---|---|---|

**Applications and Future of Composites**

Application developments – Aircrafts, missiles, space hardware, automobile, electrical and electronics, marine, recreational and sports equipment-future potential of composites.

**Future of Composites: -**General introduction and theory of nanocomposites- History of nanocomposites; Size and shape dependent properties and their uniqueness. Flexible Composites, High Temperature materials.

**Laboratory Sessions/ Experimental learning:**

**1. Evaluate the mechanical properties of a lamina and a laminate**

**Applications:** Specific Aircraft Structural components.

**Video link / Additional online information (related to module if any):**

**https://www.youtube.com/embed/PzdCymgyZ6c** - IIT Kanpur

| Module 5 | L1,L2 | 8 Hrs. |
|---|---|---|

**Composite Testing, Inspection & Quality Control**: Determination of Mechanical properties of composite materials, Testing of composites – Interlaminar Shear testing, Fracture testing, Delamination, Raw material testing. Destructive & Non-Destructive Testing, Tensile, Compression, Flexural, Shear, Hardness; ultrasonic testing – A-B-C scan

**Laboratory Sessions/ Experimental learning:**

**1.** Determination of Defects in a composite by NDT Methods

| |
|---|
| **Applications: NDT- DT Methods, Composites in Aerospace sector**<br>**Video link / Additional online information (related to module if any):**<br>8. https://youtu.be/ZMJ7O4vs-Q8 - IIT Kanpur |

| **Course outcomes:** | |
|---|---|
| Upon completion of the course, students will be able to: | |
| CO1 | Compare the properties and select material for the given application. |
| CO2 | Fabricate composite parts |
| CO3 | Apply constitutive equations of *composite* materials and understand mechanical behaviour at *micro and macro* levels. |
| CO4 | Apply the composite materials for a specific application |
| CO5 | Carry out various inspections in accordance with the established procedures and differentiate various defect types and select the appropriate **NDT** methods for better evaluation |

| **Reference Books:** | |
|---|---|
| 1. | K.K Chawla, Composite Materials- Science and Engineering, IV edition, Springer International Publishing, 2019: ISBN: 978-3-030-28983-6 |
| 2. | Autar Kaw, Mechanics of Composites, II edition, Taylor & Francis Group CRC Press. 2006, ISBN:978-0-8493-1343-1 |
| 3. | R M Jones,Mechanics of Composite Materials, 2nd Edition, Taylor & Francis, 2015; ISBN:978-1560327127 |
| 4. | Ajay Kapadia**,** Non-Destructive Testing of Composite Materials, National Composites Network, Best Practices Guide, TWI Publications, 2006. |

| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |
| CO1 | 3 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| CO2 | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO4 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| CO5 | 3 | 1 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |

High,3, Medium,2, Low,1

| | | | |
|---|---|---|---|
| **Course Title** | **AVIONICS** | **Semester** | **III** |
| **Course Code** | **MVJ22MAE335** | **CIE** | **50** |
| **Total No. of Contact Hours** | **40 L : T : P :: 3 : 1:0** | **SEE** | **50** |
| **No. of Contact Hours/week** | **4** | **Total** | **100** |
| **Credits** | **3** | **Exam. Duration** | **3 Hrs.** |

**Course objective is to:**

This course will enable students to

1. Understand the need for avionics in civil, military and space systems.
2. Acquire the knowledge of control and navigation systems
3. Acquire the knowledge of display technologies and avionics system architectures
4. Appreciate the use of microprocessors
5. Understand the functioning of data buses

| **Module 1Power Distribution System** | **L1,L2** | 8 Hrs. |
|---|---|---|

**Power Distribution System:** Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Need for Avionics in civil and military aircraft.

**Laboratory Sessions/ Experimental learning:**Programming using microprocessor

**Applications:**Data Transfer, Communication

**Video link / Additional online information (related to module if any):**

1. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

| **Module 2Inertial Navigation & Electronic Flight Control System** | **L1,L2,L3,** | 8 Hrs. |
|---|---|---|

**Inertial Navigation System:** Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing.
**Electronic Flight Control System:** Fly-by-wire system: basic concept and features. Pitch and Roll rate: command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.
**Laboratory Sessions/ Experimental learning:**Validation of truth tables for different logic circuits
**Applications:**Communication, Tracking
**Video link / Additional online information (related to module if any):**

1. https://www.coursera.org/lecture/aeronautics/basics-X8Mvf

| **Module 3Electronic Flight Instrument & Avionics Sub Systems** | **L1,L2,L3** | 8 Hrs. |
|---|---|---|

**Electronic Flight Instrument Systems:** Display-units, presentation, failure, and annunciation. Display of air data.
**Introduction to Avionics Sub Systems and Electronic Circuits:** Typical avionics sub systems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.
**Laboratory Sessions/ Experimental learning:**Construct 7 segment display circuit using IC timer
**Applications:** Attitude Estimation, Navigation, Control

| | | |
|---|---|---|
| **Video link / Additional online information (related to module if any):**<br>1. https://nptel.ac.in/courses/101/106/101106042/ | | |
| **Module 4Digital Systems & Flight Deck and Cockpits** | **L1,L2,L3** | 8 Hrs. |
| **Principles of Digital Systems:** Digital Computers, Microprocessors, Memories.<br>**Flight Deck and Cockpits:** 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, and HOTAS.<br>**Laboratory Sessions/ Experimental learning:**Data transfer using ARINC420 data bus<br>**Applications:** Position Estimation, Guidance, Control<br>**Video link / Additional online information (related to module if any):**<br>**1.** https://nptel.ac.in/courses/101/108/101108056/ | | |
| **Module 5Avionics Systems Integration** | **L1,L2,L3** | 8 Hrs. |
| **Avionics Systems Integration:** Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD1553B<br>**Laboratory Sessions/ Experimental learning:**Data transfer using MIL-STD 1553B Data bus<br>**Applications:** Navigation, Guidance, Control<br>**Video link / Additional online information (related to module if any):**<br>1. https://nptel.ac.in/courses/101/106/101106042/ | | |

**Course outcomes:**

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

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| CO1 | Understand the necessity of avionics in civil, military and space systems |
| CO2 | Understand the various aircraft navigation and control schemes |
| CO3 | Appreciate the use of electronics packages in avionics |
| CO4 | Understand the principles of various man machine interface devices such as data entry and displays. |
| CO5 | Get introduced with the avionics systems and work with the various existing aircraft data buses. |

Reference Books:


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| 1. | R.P.G. Collinson, Introduction to Avionics Systems, 3rd Edition, 2011, Springer. |
| 2. | Ian Moir, Allan Seabridge and Malcolm Jukes, Civil Avionics Systems, 2nd Edition, 2003, Wiley. |
| 3. | R. Cundy Dale, Introduction to Avionics, 2010, Pearson Education. |


| CO,PO Mapping | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 |

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| CO1 | | | | | | | | 2 | | | | 2 | 3 | 2 |
| CO2 | | | | | | | | | | | | 2 | 1 | |
| CO3 | 2 | 2 | 2 | | | | | | | | | 2 | | |
| CO4 | 3 | 3 | 2 | | | 2 | 2 | | | | | 3 | 2 | 1 |
| CO5 | 3 | 3 | 3 | | | 2 | 2 | | | | | 3 | 3 | 3 |

High,3, Medium,2, Low,1