MVJ College of Engineering, Whitefield, Bangalore

An Autonomous Institution, Affiliated to VTU, Belagavi

Scheme of Teaching and Examination 2020-21

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

Effective from the academic year 2020-21

I SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course Type	Code	Course Title	Teaching Department	Theory Lecture (L)	Tutorial (T)	Practical/Drawing (P)	Duration in Hours	CIE Marks	SEE Marks	Total marks	Credits
1	PC	MVJ20MAE11	Applied Mathematics	AE	3	2	-	3	50	50	100	4
2	PC	MVJ20MAE12	Applied Computational Fluid Dynamics	AE	3	2	-	3	50	50	100	4
3	PC	MVJ20MAE13	Aerodynamics	AE	3	2	-	3	50	50	100	4
4	PC	MVJ20MAE14	Introduction to Aerospace Vehicles and Systems	AE	3	-	-	3	50	50	100	3
5	PC	MVJ20MAE15	Aerospace Propulsion	AE	3	-	-	3	50	50	100	3
6	PC	MVJ2MAEL16	Aerodynamic Lab	AE	-	-	3	3	50	50	100	2
7	PC	MVJ20MAEL17	Propulsion Lab	AE	-	-	3	3	50	50	100	2
8	IPR	MVJ20MAE18	Research Methodology & IPR	AE	-	-	2	3	50	50	100	2
			Total		15	6	8	24	400	400	800	24

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Scheme of Teaching and Examination 2020-21

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

Effective from the academic year 2020-21

II SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course Type	Course Code	Course Title	Teaching Department	Teaching hours/week Lecture L	Teaching hours/week Tutorial T	Teaching hours/week Practical/Drawing P	Duration in Hours	CIE Marks	SEE Marks	Total marks	Credits
1	PC	MVJ20MAE21	Aircraft Performance & Flight Mechanics	AE	3	1	-	3	50	50	100	4
2	PC	MVJ20MAE22	Airframe Structures and Structural Design	AE	3	1	-	3	50	50	100	4
3	PC	MVJ20MAE23	Aircraft Flight Dynamics & Automatic Flight Control	AE	3	1	-	3	50	50	100	4
4	PC	MVJ20MAE24	Flight Vehicle Design	AE	3	1	-	3	50	50	100	4
5	PE	MVJ20MAE25X	Professional Elective-I	AE	3	-	-	3	50	50	100	3
6	PE	MVJ20MAE26X	Professional Elective-II	AE	3	-	-	3	50	50	100	3
7	PC	MVJ20MAEL27	Structures Lab	AE	-	-	3	3	50	50	100	2
8	Sem	MVJ20MAE28	Technical Seminar	AE	-	-	2	-	100		100	2
			Total		18	4	5	21	450	350	800	26

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Effective from the academic year 2020-21

Note: PC: Professional Core Course, PE: Professional Elective Course

Professional Elective-I		Professional Elective-II	
Course Code	Course Title	Course Code	Course Title
MVJ20MAE25X		MVJ20MAE26X	
MVJ20MAE251	Artificial Intelligence and Robotics	MVJ20MAE261	Fatigue and Fracture Mechanics
MVJ20MAE252	Theory of Aero elasticity	MVJ20MAE262	Hypersonic Flows
MVJ20MAE253	Theory of Plates and Shells	MVJ20MAE263	Composite Materials and Fabrication Techniques

Note:

1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide in any and a senior faculty of the department. Participation in seminar by all postgraduate students of the same and other semesters of the programme shall be mandatory.
The CIE marks awarded for Technical Seminar, shall be based on the evaluation of Seminar Report, Presentation skill and Question And Answer session in the ratio 50:25:25.

Probability & Statistics-Prerequisite for the MVJ20MAE252 Course

Properties of probability function, conditional probability, Law of total probability and Bayer`s rule, discrete and continuous random variables, expectations and variance, covariance. Normalization techniques, Principle component analysis, Correlations, Multi Co linearity, Data Imputation techniques, Visualization techniques for different types of data (Box plot, histogram, contour plot etc). Computations with more random variables. Basic Statistical models, distribution features, linear regression models, Logistic Regression, Lasso Regression, Ridge Regression, Random Forest, XGboost , maximum likely hood principles, method of least square and its relation with maximum likelihood

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Scheme of Teaching and Examination 2020-21

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

Effective from the academic year 2020-21

III SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course Type	Course Code	Course Title	Teaching Department	Teaching hours/week Theory Lecture L	Teaching hours/week Tutorial T	Teaching hours/week Practical/Drawing P	Duration in Hours	CIE Marks	SEE Marks	Total marks	Credits
1	PC	MVJ20MAE31	Minor Project	AE	-	-	3	3	50	50	100	4
2	PC	MVJ20MAE32	Major Project Phase-1	AE	-	-	3	3	50	50	100	4
3	PC	MVJ20MAEI33	Internship	AE	-	-	2	3	50	50	100	10
			Total				8	9	150	150	300	18

Note:
1. **Major Project Phase-1:** Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.

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Scheme of Teaching and Examination 2020-21

Outcome Based Education (OBE) and Choice Based Credit System (CBCS)

Effective from the academic year 2020-21

IV SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course		Course Title	Teaching Department	Teaching hours/week			Examination				Credits
	Type	Code			Lecture Theory (L)	Tutorial (T)	Practical/Drawing (P)	Duration in Hours	CIE Marks	SEE Marks	Total marks	
1	PC	MVJ20MAEP41	Major Project Phase-2		-	-	4	3	50	50	100	18
			Total				4	3	50	50	100	18

Note:
1. Major Project Phase-2:
CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and Question and Answer session in the ratio 50:25:25.
SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check.

Course Title	APPLIED MATHEMATICS	Semester	I
Course Code	MVJ20MAE11	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:

- Acquire Knowledge of Numerical Differentiation and Integration
- Understand Tensors and Algebra of Tensors
- Gain Knowledge of Optimisation Techniques
- Understand the Application of Variational Methods

Module 1	L1,L2,L3	10 Hrs.

Numerical Differentiation & Integration

Numerical Differentiation – Formulae for derivatives, differentiation via interpolation, method for undetermined coefficients, Richardson`s extrapolation.

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.

Applications: Analysis techniques in Aeronautical field

Video link :https://www.youtube.com/watch?v=0rtaUUonwkU

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

Module 2	L1,L2,L3,	10 Hrs.

Multilinear Algebra

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; Quotien tlaw. Application-Inertia tensor, stress tensor, contravariance of stress tensor.

Applications: Flow simulation, Structural analysis, Stability & Control of flight vehicles

Video link :https://www.youtube.com/watch?v=0rtaUUonwkU

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

Module 3	L1,L2,L3	10 Hrs.

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, and Quadratic programming.

Applications: Aerodynamic optimisation, Structural optimisation, Multi-disciplinary optimisation

Video link :https://www.youtube.com/watch?v=dPQKltPBLfc

https://www.youtube.com/watch?v=WNfpj2oiAu4

https://www.youtube.com/watch?v=AcXMioRz6s8

Module 4	L1,L2,L3	10 Hrs.

Variational Methods-1

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.

Application: Development and Solution of Differential equations

Link:https://www.youtube.com/watch?v=FtHzJx_nDSY

https://www.youtube.com/watch?time_continue=9&v=QXxr5kTI4c4&feature=emb_title

Module 5	L1,L2	10 Hrs.

Variational Methods-2

Use of second variation in Extremum problems, necessary and sufficient conditions for extremum. Du Bois-Reymond`s theorem. Function of several variables, Dirichlet` principle, Eigenvalue problem formulation as a variational problem.

Application: Development and Solution of Differential equations.

Link: https://www.youtube.com/watch?v=FtHzJx_nDSY

https://www.youtube.com/watch?time_continue=9&v=QXxr5kTI4c4&feature=emb_title

Course outcomes:

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

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	APPLIED COMPUTATIONAL FLUID DYNAMICS	Semester	I
Course Code	MVJ20MAE12	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:		
• 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

Applications: Flow analysis using Finite Difference Techniques

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

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.

Laboratory Sessions/ Experimental learning: Ansys Lab

Applications: Body fitting Grid generation

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.

Laboratory Sessions/ Experimental learning: Ansys Lab

Applications: Adaptive Grid formulation

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

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	AERODYNAMICS	Semester	I
Course Code	MVJ20MAE13	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:

- 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 standard Airplane 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 standard Airplane 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 standard Airplane 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 perturbation theory. 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 standard Airplane 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

Course Title	INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS	Semester	I
Course Code	MVJ20MAE14	CIE	50
Total No. of Contact Hours	40L : 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. 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):		
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.

Laboratory Sessions/ Experimental learning: NA

Applications: weaponry, ejection seats, launch vehicles for artificial satellites, human spaceflight, and space exploration

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

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.

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.

Laboratory Sessions/ Experimental learning: NA

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):

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.

Introduction to Airport Engineering: Development of air transportation,

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

Laboratory Sessions/ Experimental learning: NA

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

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

https://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	AEROSPACE PROPULSION	Semester	I
Course Code	MVJ20MAE15	CIE	50
Total No. of Contact Hours	40L : 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:

- 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 Engine SimApplet Version 1.8a (latest edition) by using [Beginner's Guide to Propulsionhttps://www.grc.nasa.gov/WWW/K-12/airplane/ngnsim.html](https://www.grc.nasa.gov/WWW/K-12/airplane/ngnsim.html)

2.   Calculate and draw the performance curves using Engine Sim Applet Version 1.8a

Applications: Performance and efficiency calculation in airplane engines 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_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 Electric Thrusters, 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 a typical 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	AERODYNAMICS LAB	Semester	I
Course Code	MVJ20MAEL16	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:

  o   Be acquainted with basic principles of aerodynamics using wind tunnel.
  o   Acquire the knowledge on flow visualization techniques.
  o   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	L1,L2,L3	03

	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		
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

Course Title	AIRCRAFT PROPULSION LABORATORY	Semester	I
Course Code	MVJ20MAEL17	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:

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
3	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
9	Fuel - injection characteristics (spray cone geometry; spray speed etc. for various type of injectors)	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

14	Effect of inlet flow conditions on under-expanding /over-expanding nozzle.	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	RESEARCH METHODOLOGY ANDIPR	Semester	I
Course Code	MVJ20MAE18	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	2	Exam. Duration	3 Hrs.

Course objective is to:

- Study an overview of research methodology and explain techniques of defining a research problem
- Learn the functions of literature review in research and research design
- Describe the details of sampling designs, measurement and scaling techniques.
- Illustrate several parametric tests of hypotheses and Chi-square test.
- 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:

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.   Determine the sources of error analysis in the research methods Applications: 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 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	AIRCRAFT PERFORMANCE & FLIGHT MECHANICS	Semester	II
Course Code	MVJ20MAE21	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:

- 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):		
https://nptel.ac.in/courses/101106041/Module 5 to Module 10 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,

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

Laboratory Sessions/ Experimental learning: Estimation of Static Stability Derivatives at various speeds

Applications

Applicable in standard Airplane Design

Video link / Additional online information (related to module if any):
https://nptel.ac.in/courses/101106043/Module 1 to 4

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.

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.

Laboratory Sessions/ Experimental learning:

Estimation of Static stability derivatives at various speeds **Applications**

Applicable in standard Airplane Design

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

https://nptel.ac.in/courses/101106043/Module 5 to Module 6

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 STRUCTURES AND STRUCTURAL DESIGN	Semester	II
Course Code	MVJ20MAE22	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. Understand the fundamentals of Buckling and stability as applied to aircraft 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	AIRCRAFT FLIGHT DYNAMICS & AUTOMATIC FLIGHT CONTROL	Semester	II
Course Code	MVJ20MAE23	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 Concept of control and airframe parameters
2. Acquire knowledge of vehicles equations of motion and stability parameters
3. Gain knowledge of pitch, roll and yaw analysis
4. Understand the feedback control for pitch, roll, and yaw of airplanes
5. Learn autopilot techniques for pitch, roll, and yaw of airplanes

Module 1		L1,L2,L3	10 Hrs.

Review of feedback system analysis and aerodynamic fundamentals: Mathematical models of linear open loop and closed loop systems. Transfer functions. Stability of open and close loops-Bode plot, root locus method, Nyquist criteria. 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. Aircraft static and dynamic stability-review.

Laboratory Sessions/ Experimental learning: MAT Lab

Applications: Flight Control system stability

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

Nptel Video: Flight Dynamics by Dr.Nandan Kumar Sinha IIT Madras

Module 2		L1,L2,L3,	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 linarized equations of motion, description of dimensional and non-dimensional stability axis derivatives. Perturbed forces and moment derivatives. Recasting equations of motion in acceleration format.

Laboratory Sessions/ Experimental learning: MAT Lab

Applications: Development of Equations of Motion of Aircraft

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

Nptel Video: Flight Dynamics by Dr.Nandan Kumar Sinha IIT Madras

Module 3	L1,L2,L3	10 Hrs.

Longitudinal dynamics: Review of simplifying assumptions and derivation of simplified longitudinal equations of motion in Laplace form, 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 in Laplace form, lateral controls and control input transfer functions, two degrees of freedom Dutch roll approximations, typical example transfer functions of conventional aircraft and their responses.

Laboratory Sessions/ Experimental learning: MAT Lab

Applications: Analyses of Longitudinal and Lateral motions of Aircraft

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

Nptel Video: Flight Dynamics by Dr.Nandan Kumar Sinha IIT Madras

Module 4	L1,L2,L3	10 Hrs.

Classical Feedback Control- Position feedback, rate feedback, and acceleration feedback. Root locus analysis with possible locations of adjustable gain. Longitudinal stability Augmentation- Pitch attitude feedback, Pitch rate feedback, velocity feedback, incidence angle feedback and normal acceleration feedback to elevator. Lateral-Direction stability Augmentation- Sideslip feedback, roll rate feedback, yaw rate feedback, roll attitude feedback, and yaw attitude feedback to aileron. Sideslip angle feedback, roll rate feedback, yaw rate feedback, roll attitude feedback, and yaw attitude feedback to rudder.

Laboratory Sessions/ Experimental learning: MAT Lab

Applications: Development of Feedback Control Systems.

Video link / Additional online information (related to module if any):   Nptel Video: Flight Dynamics by Dr.Nandan Kumar Sinha IIT Madras

Module 5	L1,L2	10 Hrs.

Aircraft Stability and control Augmentation. Inner loop stability and control. Typical inner loop systems-yaw damper, pitch damper, angle-of-attack feedback, load factor feedback. Outer loop Autopilot/Navigation control loop. Pitch attitude hold, Altitude hold, Bank angle hold, heading hold. Compensation filters-lead compensators, lag compensators, Lead-lag compensators, stability realization through compensators. Autopilots-basic principles- Height control, heading control autopilots, examples. ILS coupled Autopilot control-Flight path Kinematics, ILS localizer

coupling loop, ILG glide slope coupling loop. Automatic landing. Visibility categories and autopilot requirements. Automatic flare control.

Laboratory Sessions/ Experimental learning: MAT Lab

Applications: Augmentation of aircraft stability for various flight phases.

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

Nptel Video: Flight Dynamics by Dr.Nandan Kumar Sinha IIT Madras

Course outcomes:	
Upon completion of the course, students will be able to:	
CO1	Demonstrate the concepts of control for aircraft application
CO2	Develop equations of motion and apply appropriate approximation
CO3	Analyze pitch, roll and yaw motions
CO4	Evaluate feedback control for pitch, roll and yaw motions
CO5	Apply automatic flight control for pitch, roll and yaw motions

Reference Books:	
1.	Nelson, R.C., Flight Stability and Automatic Control, McGraw-Hill Book Co., 2007
2.	Babister, A. W, Aircraft dynamic Stability and Response, Pergamon Press, Oxford, 1980.

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	FLIGHT VEHICLE DESIGN	Semester	II
Course Code	MVJ20MAE24	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:

- Understand the overview of aircraft design process
- Acquire knowledge of configuration layout and design of structural components
- Analyses engine selection and carry out control surface sizing
- Understand design aspects of subsystems

Module 1		L1,L2,L3	10 Hrs.

Overview of Design Process: Introduction, Standards & Specifications, 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

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

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

Module 2		L1,L2,L3,	10 Hrs.

Configuration Layout & loft

Aerodynamic shape optimisation ,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

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,L3	10 Hrs.

Engine Selection & Flight Vehicle Performance

Engine selection criteria, 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

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

Module 4	L1,L2,L3	10 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 :

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

Module 5	L1,L2	10 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

Laboratory Sessions/ Experimental learning: Assemble the CAD models of the components and verify performance using CFD tool in Ansys lab.

Applications: Analyse design issues for aerodynamics, propulsion, structure, weights, stability, cost, and performance and generate a layout.

Video link :

1.https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/10110 8047/lec29.pdf

Course outcomes:	
Upon completion of the course, students will be able to:	
CO1	Define a configuration for given specifications i.e. thrust to weight ratio and wing loading
CO2	Solve problems related to configuration layout & airframe components sizing
CO3	Workout engine selection and perform stability analysis
CO4	Model subsystems
CO5	Understand and Comprehend the complexities involved during development of flight vehicles

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	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	ARTIFICAL INTELLIGENCE AND ROBOTICS	Semester	II
Course Code	MVJ20MAE251	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:

- Understand the Propositional Logic in Artificial Intelligence.
- Acquire the knowledge of Machine Learning and Data Mining.
- Gain knowledge on the fundamentals of data analysis and neural networks.
- Gain Knowledge of Robotics Kinematics
- Understand Robotics sensors, actuators and drive systems.

Module 1	L1,L2,L3	08 Hrs.

Introduction & Propositional Logic: History of AI, Propositional logic Computability& Complexity, Applications, Ist Order Predicate logic, limitations of logic, modelling uncertainties. Logic Programming: Prolog system & Implementation, Execution control, Constraint Logic programming, Planning and examples.

Laboratory Sessions/ Experimental learning:

AI based computer simulation lab

Applications: Aanalyse the relationship between a fact, a statement that is true, and a rule, which is a conditional statement.

Video link / Additional online information:

https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-me71/

Module 2	L1,L2,L3,	08 Hrs.

Machine Learning and Data Mining: Data analysis, learning rule, nearest neighbor method, Decision tree learning, Clustering-Distance matrices, Hierarchical learning. Neural Networks: Mathematical Model, Neural associative memory, spelling correction program, support vector machine, application of deep learning, application of neural network.

Laboratory Sessions/ Experimental learning: AI based computer simulation lab

Applications: Data mining and data analysis can improve the efficiency of robots in the domain of sensor data collection, procession and meaningful execution of the obtained data.

Video link / Additional online information:

https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-me71/https://nptel.ac.in/noc/courses/noc20/SEM1/noc20-ge09/

Module 3	L1,L2,L3	08 Hrs.

Robotics: Introduction, fundamentals, classification, degrees of freedom, degrees of motion, manipulation of Robot components, joints , symbols, robot configuration, robot programming methods. Mathematical representation of robots, kinematics of serial manipulators, kinematics of parallel manipulators, dynamics of manipulators.

Laboratory Sessions/ Experimental learning:

AI based computer simulation lab

Applications: Application of mathematical principals and basics dynamics of robots will be applied in developing better and much efficient robots of specific applications.

Video link / Additional online information: https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-me61/

Module 4	L1,L2,L3	08 Hrs.

Trajectory Planning & Motion Control Systems: Path versus trajectory, joint space versus Cartesian space description, basic trajectory planning, joint space trajectory planning, Cartesian –space trajectory. Motion Control System: Basic components & terminologies, proportional controllers, open-loop versus closed loop, applications, electromagnetic systems dynamics, multi input-multi output systems.

Laboratory Sessions/ Experimental learning:

AI & robotics-based computer simulation lab

Applications: For efficient synthesis of optimum controls strategies of robots. Video link / Additional online information https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-ee41/

Module 5	L1,L2	08 Hrs.

Robot Sensors and Actuators: Internal sensors, external sensors, force sensors, thermocouples, acceleration sensors, torque sensors, hydraulic and pneumatic actuators, electrical actuators, servo motors, stepper motors, micro actuators & motors, displacement transducers, comparison of actuating systems. Drive Systems: Motion conversion & dividers-rotation to linear motion, harmonic dividers, and dynamics of a robot.

Laboratory Sessions/ Experimental learning:

AI based computer simulation lab

Applications: To be applied on the basics design and development of an application-oriented robot in component selection and modelling of subsystems.

Video link / Additional online information: https://nptel.ac.in/noc/courses/noc18/SEM2/noc18-me61/

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

CO1	Apply the Propositional Logic in Artificial Intelligence
CO2	Perform data mining
CO3	Understand the fundamentals of data analysis and neural networks.
CO4	Model Robotic kinematics
CO5	Apply the knowledge of Robotics sensors, actuators and drive systems

Reference Books:	
1.	Wolfgang Ertel, Introduction to Artificial Intelligence, Springer, 2017.
2.	AppuKuttan K.K., Robotics, I K International Publishing House, Pvt. Ltd. 2012
3.	Vinod Chandra S.S., and AnandHareendran S, Artificial Intelligence and Machine Learning, PHI Learning Pvt. Ltd., 2014.
4.	Saeed B Niku, Introduction to Robotics-Analysis, Control, Application, Wiley, 2011.

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	MVJ20MAE252	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:

- 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:

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:

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:

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
2. First mode: Wing bending
3. Third mode: Aileron deflection Video links:

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

Course outcomes:	
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 PLATES AND SHELLS	Semester	II
Course Code	MVJ20MAE253	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:

- Understand the stresses developed in plates under bending
- Learn the stresses developed in plates under buckling
- Learn the stresses developed in shells under bending
- Acquire the knowledge of the stresses developed in shells under buckling

Module 1	L1,L2,L3	08 Hrs.

Introduction: Plate and Shell Structures in Aerospace Vehicles. Flexural rigidity of plates. Flexural rigidity of shells. Introduction to bending and buckling of plates and shells. Reinforced plates. Eccentrically compressed shells. Bending of Thin Plates - Pure bending of plates. Isotropic and orthotropic flat plates. Flexural rigidity of plate. Bending of plates by distributed lateral load. Combined bending and tension or compression. Bending and twisting moments. Shear stress.

Laboratory Sessions/ Experimental learning:

1. 3 point Flexural testing
2. 4 point flexural testing

Applications:

1. Application in wings section of aircrafts
2. Application in automobile (Mechanical Engineering)

Video link / Additional online information:

1. Introduction https://www.youtube.com/watch?v=kpAnsW-WB58&feature=emb_logo
2. Classification of plate theory

https://www.youtube.com/watch?v=WZN8SDXOX5Q&feature=emb_logo

Module 2	L1,L2,L3,	08 Hrs.

Bending Of Thin Plates - Strain Energy, Slopes of deflection of surface. Different edge conditions: - built in edge, simply supported edge and, free edge. Combined bending and tension or compression of plates. Strain energy by: – bending of plates, bending by lateral loads,

combined bending and tension or compression of plates. Buckling Of Thin Plates:- Method of calculation of critical loads. Buckling of simply supported rectangular plates uniformly compressed in one direction. Buckling of uniformly compressed rectangular plates simply supported along two opposite sides perpendicular to the direction of compression and having various edge conditions along the other two sides. Critical values of compressive stress.

Laboratory Sessions/ Experimental learning:

1. Strain energy and slopes of deflection of surface plotting using computer softwares

2. Structural Modeling of Sandwich Beam of Rectangular Cross-section and Analyses for Stress for Unsymmetrical bending case

Applications:

1. Application in fuselage section of aircrafts

2. Application in Car outer body coverings (Mechanical Engineering)

Video link / Additional online information:

1. Energy Principles

https://www.youtube.com/watch?v=02p5T_WCre0&feature=emb_logo

Transformation of tensors

https://www.youtube.com/watch?v=qaOzuDTQVBU&feature=emb_logo

Module 3	L1,L2,L3	08 Hrs.

Buckling of Reinforced Plates: Stability of plates reinforced by ribs. Simply supported rectangular plates with longitudinal ribs. General equation for critical compressive stress. Critical compressive stress for a plate stiffened by one rib. Study of the experimental value of buckling of plates.

Bending of Thin Shells: Deformation of an element of a shell. Expression for components of normal stresses. Flexural rigidity of shell. Case of deformation with presence of shearing stresses.

Laboratory Sessions/ Experimental learning:

1.Buckling of thin plates and studying the effects using ansys2.Bending of thin shell and studying the effects using ansys

Applications:

1. Aircrafts wing and fuselage

2. In automobile leaf spring

3. Vents for air conditioning

Video link / Additional online information:

1.Governing equations

https://www.youtube.com/watch?v=q_yiBXCBL8w&feature=emb_logo

2.Governing equations of a plate

https://www.youtube.com/watch?v=-rv3jOHe7RY&feature=emb_logo

Module 4	L1,L2,L3	08 Hrs.

Strain Energy of Deformation Of Shells: Strain energy of deformation of shell:bending and stretching of middle surface. Symmetrical deformation of a circular cylindrical shell. Differential equation for bending of strip. Unsymmetrical deformation of a circular cylindrical shell.

Laboratory Sessions/ Experimental learning:

1.Strain energy deformation in shells and studying the effects using ansys2.Bending of strip and studying the effects using ansys

Applications:

1. In aircraft fuselage
2. Water containers
3. Oil containers
4. Concrete mixers

Video link / Additional online information:

1. Reduced stiffnesshttps://www.youtube.com/watch?v=QTHrs8nqo18&feature=emb_logo

Navier solution https://www.youtube.com/watch?v=yNMfqsoSLEw&feature=emb_logo

Module 5	L1,L2	08 Hrs.

Buckling of Shells: Symmetrical buckling of cylindrical shell under the action of uniform axial compression:-differential equation, critical stress. Symmetrical buckling of cylindrical shell under the action of uniform axial pressure. Unsymmetrical buckling of cylindrical shell under the action of uniform axial pressure. Study of the experimental values of cylindrical shells in axial compression. Bent or eccentrically compressed shells.

Laboratory Sessions/ Experimental learning:

1.   Symmetrical buckling of cylindrical shell subjected to uniform axial compression in Ansys

2.   Unsymmetrical buckling of cylindrical shell subjected to uniform axial compression in Ansys

Applications:

1.   Fuselage of aircrafts

2.	Large vertical Storage tanks

Vertical containers

Video link / Additional online information:

1.	Levy solutionhttps://www.youtube.com/watch?v=ipTErjTeCmY&feature=emb_logo

Buckling of plateshttps://www.youtube.com/watch?v=S11B2-qaWPc&feature=emb_logo

Course outcomes:

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

CO1	Estimate the stresses developed in plates and shells under bending
CO2	Analyse the stresses developed in thin plates under buckling
CO3	Analyse the stresses developed in shells under buckling and bending
CO4	Calculate strain energy deformation in shells
CO5	Analyse symmetrical and unsymmetrical buckling in shell

Reference Books:	
1.	Timoshenko, S.P. and Gere, J.M., Theory of Elastic Stability, McGraw-Hill Book Co. 1986
2.	Timoshenko, S.P. Winowsky. S., and Kreger, Theory of Plates and Shells, McGrawHill Book Co. 1990
3.	Flugge, W. , Stresses in Shells, Springer – Verlag, 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	FATIGUE AND FRACTURE MECHANICS	Semester	II
Course Code	MVJ20MAE261	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:

- Understand the principles of fracture mechanics and the stress analysis of members with cracks.
- Acquire knowledge of plastic fracture mechanics.
- Understand the principles of dynamics and crack arrest.
- Acquire the knowledge of fatigue and fatigue crack growth rate and fracture resistance of materials.
- Understand the numerical methods of computational fracture mechanics and fracture toughness of materials

Module 1		L1,L2,L3	08 Hrs.

Fracture Mechanics Principles: Introduction, Mechanisms of Fracture, a crack in a structure, the Graffiti's criterion, modem design, - strength, stiffness and toughness. Stress intensity approach. Stress Analysis for Members with Cracks: Linear elastic fracture mechanics, Crack tip stress and deformations; Relation between stress intensity factor and fracture toughness, Stress intensity based solutions. Crack tip plastic zone estimation, Plane stress and plane strain concepts. Dugdale approach, the thickness effect.

Laboratory Sessions/ Experimental learning: Conduct the experiment of stress analysis for members with cracks.

Applications: To apply the fracture mechanics principles in aircraft structural design.

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

https://nptel.ac.in/courses/112106065/https://nptel.ac.in/courses/113107078/

http://www.nptelvideos.in/2012/12/engineering-fracture

Module 2		L1,L2,L3,	08 Hrs.

Elastic - Plastic Fracture Mechanics: Introduction, Elasto-plastic factor criteria, crack resistance curve, I-integral, Crack opening displacement, crack tip opening displacement. Importance of R-curve in fracture mechanics, Experimental determination of I-integral, COD and CTOD.

Laboratory Sessions/ Experimental learning: Conduct the experimental determination of specimen using COD and CTOD. Applications: To find and solve the elastic plastic fracture of the aircraft structure. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/112106065/https://www.youtube.com/watch?v=81ttaX6pmt4		
Module 3	L1,L2,L3	08 Hrs.
Dynamic and Crack Arrest: Introduction, the dynamic stress intensity and elastic energy release rate, crack branching, the principles of crack arrest, and the dynamic fracture toughness. Laboratory Sessions/ Experimental learning: Conduct the experimental study of dynamic fracture toughness of a specimen. Applications: To determine the dynamic and crack arrest of the structural materials. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/112106065/		
Module 4	L1,L2,L3	08 Hrs.
Fatigue and Fatigue Crack Growth Rate: Fatigue loading, Various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws. Fracture Resistance of Materials: Fracture criteria, fatigue cracking criteria, effect of alloying and second phase particles, effect of processing and anisotropy, effect of temperature, closure. Laboratory Sessions/ Experimental learning: • Conduct the experiment on material testing of the specimen using fatigue test. Applications: To predict the the fatigue strength of the aircraft parts. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/112106065/https://nptel.ac.in/courses/113107078/		
Module 5	L1,L2	08 Hrs.
Computational Fracture Mechanics: Overview of numerical methods, traditional methods in computational fracture mechanics – stress and displacement marching, elemental crack advance, virtual crack extension, the energy domain integral, finite element implementation. Limitations of numerical fracture analysis, Fracture Toughness testing of metals: Specimen size requirements, various test procedures, effects of temperature, loading rate and plate thickness on fracture toughness. Fracture testing in shear modes, fatigue testing and NDT methods. Laboratory Sessions/ Experimental learning: • Perform the numerical methods in computational fracture mechanics.		

- Conduct the experiment on non destructive testing of metals.

Applications: To perform the computational analysis in fracture mechanics and to determine the fatigue and fracture testing of the aircraft materials. Video link / Additional online information (related to module if any):

https://nptel.ac.in/courses/112106065/

Course outcomes:

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

CO1	Apply the principles of fracture mechanics and the stress analysis of members with cracks.
CO2	Solve the problems related to plastic fracture mechanics.
CO3	Examine the principles of dynamics and crack arrest.
CO4	Analyze the problems related to fatigue and fatigue crack growth rate and fracture resistance of materials.
CO5	Analyze the numerical methods of computational fracture mechanics and fracture toughness of materials.

Reference Books:	
1.	Karen Helen, Introduction to Fracture Mechanics , McGraw Hill Pub 2000.
2.	Jayatilake , Fracture of Engineering Brittle Materials , Applied Science, London.2001.
3.	T. L. Anderson , Fracture Mechanics Application -, CRC press 1998.
4.	David Broek, and ArtinusNijhoff, Elementary Engineering Fracture of Mechanics-, London 1999.

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	HYPERSONIC FLOWS	Semester	II
Course Code	MVJ20MAE262	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:		
• 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.   The Hypersonic Wind Tunnel (HWT) operates at Mach 5, 8, and 14 with stagnation 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	COMPOSITE MATERIALS AND FABRICATION TECHNIQUES	Semester	II
Course Code	MVJ20MAE263	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:

- 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	08 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

. **Laboratory Sessions/ Experimental learning**: Optional

Applications: Composites are latest application in Aeronautical and Aerospace.

Video link / Additional online information:

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

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

Fabrication of Composite Structures: Cutting, machining, drilling, mechanical fasteners and adhesive bonding, joining, computer-aided design and manufacturing, tooling, fabrication equipment **Macro-Mechanical Behavior of a Lamina**: Stress-strain relation for an orthotropic lamina- Restriction on elastic constants-Strengths of an orthotropic lamina and Failure theories for an orthotropic lamina.

Laboratory Sessions/ Experimental learning: Optional **Applications**: fabrication of aircraft structural components **Video link / Additional online information**:

https://swayam.gov.in/nd1_noc19_me67/

Module 4	L1,L2,L3	08 Hrs.

Micro-Mechanical Behaviour of a Lamina, Determination of elastic constants-Rule of mixtures, transformation of coordinates, micro-mechanics based analysis and experimental determination of material constants.

Macro-Mechanical Behaviour of a Laminate: Classical plate theory- Stress and strain variation in a laminate- Resultant forces and moments- A B & D matrices- Strength analysis of a laminate.

Laboratory Sessions/ Experimental learning: Optional **Applications**: Aeronautical and Aerospace applications **Video link / Additional online information**:

https://slideplayer.com/slide/2389089/

Module 5	L1,L2	08 Hrs.

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: One **application** is in the ventral fins for the aircraft

Video link / Additional online information: http://www.infocobuild.com/education/audio-video-courses/mechanicalengineering/ManufacturingOfComposites-IIT-Kanpur/lecture-17.html

Course outcomes:

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

CO1	Characterize the composite materials for application
CO2	Fabricate composite parts
CO3	Apply advance processing techniques
CO4	Analysing the micro and macro behaviour of laminates
CO5	Application of MMCs in Aerospace

Reference Books:	
1.	K.K Chawla, Composites Science and Engineering, Springer Verlag, 1998
2.	R M Jones, " Mechanics of Composite Materials", McGraw-Hill, New York, 1975
3.	MeingSchwaitz, Composite materials hand book, McGraw Hill Book Company. 1984
4.	John Wenbag, Composite Materials Fabrication`, Wolfgang Publications, 21 April 2011

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	STRUCTURES LAB	Semester	II
Course Code	MVJ20MAEL27	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:

- Familiarize with various structural experiment facilities
- Familiarize with different structural experiments
- Conduct the test acquire the data and analyse
- Determine the shear flow in different sections
- Understand the vibration analysis of the structural members

Sl No	Experiment Name	RBT Level	Hours
1	Determine the Bending Modulus of sandwich Beam	L1,L2,L3	03
2	Tensile, compressive and flexural testing of a composite material part.	L1,L2,L3	03
3	Determination of natural frequency and mode shapes of a cantilever beam for the following cases. Constant cross section . Varying cross section Constant cross section and varying stiffness	L1,L2,L3	03
4	Determining of Shear centre through shear flow measurement for following cases.　　　　a. Close section – Symmetrical bending 　　　　　b. Open section – Unsymmetrical bending	L1,L2,L3	03
5	Determine the index factor `K` in a tensile filed of Wagner Beam Structural Modelling of a 3D Wing.	L1,L2,L3	03
6	Structural Modelling of fuselage bulk head of an aircraft.	L1,L2,L3	03
7	Determine the Shear flow analysis under defined load conditions on a spar of 3D wing.	L1,L2,L3	03
8	Determine the Shear flow analysis under defined load conditions in a bulkhead.	L1,L2,L3	03
9	Estimation of shear flow in a plate of varying stiffness under bending and torsion.	L1,L2,L3	03
10	Free and forced vibration analysis of a structural frame.	L1,L2,L3	03

11	Analysis of active vibration control in a smart material part.	L1,L2,L3	03
12	Experimental determination of behaviour of a composite beam subjected to combined loading.	L1,L2,L3	03

Course outcomes:	
CO1	Demonstrate various experiment facilities
CO2	Explain the use of different measurement techniques
CO3	Perform the test, acquire the data, analyse and document

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