MVJ College of Engineering, Whitefield, Bangalore

An Autonomous Institution, Affiliated to VTU, Belagavi

Scheme of Teaching and Examination 2019-20

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

Effective from the academic year 2019-20

I SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course		Course Title	Teaching Department	Teaching hours/week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in Hours	CIE Marks	SEE Marks	Total marks	
	Type	Code			L	T	P					
1	PCC	MVJ19MAE11	Applied Mathematics	AE	3	2	-	3	50	50	100	4
2	PCC	MVJ19MAE12	Aerodynamics	AE	3	2	-	3	50	50	100	4
3	PCC	MVJ19MAE13	Introduction to Aerospace Vehicles and Systems	AE	3	2	-	3	50	50	100	4
4	PCC	MVJ19MAE14	Aerospace Propulsion	AE	3	2	-	3	50	50	100	4
5	PCC	MVJ19MAE15	Research Methodology & IPR	AE	2	-	-	3	50	50	100	2
6	PCC	MVJ19MAEL16	Aerodynamic Lab	AE	-	-	3	3	50	50	100	2
7	PCC	MVJ19MAEL17	Propulsion Lab	AE	-	-	3	3	50	50	100	2
				Total	14	8	6	21	350	350	700	22

II SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course		Course Title	Teaching Department	Teaching hours/week			Examination				Credits
	Type	Code			Theory Lecture L	Tutorial T	Practical/ Drawing P	Duration in Hours	CIE Marks	SEE Marks	Total marks	
1	PCC	MVJ19MAE21	Aircraft Performance & Flight Mechanics	AE	3	2	-	3	50	50	100	4
2	PCC	MVJ19MAE22	Applied Computational Fluid Dynamics	AE	3	2	-	3	50	50	100	4
3	PCC	MVJ19MAE23	Airframe Structures and Structural Design	AE	3	2	-	3	50	50	100	4
4	PEC	MVJ19MAE24X	Professional Elective-I	AE	3	2	-	3	50	50	100	4
5	PEC	MVJ19MAE25X	Professional Elective-II	AE	3	2	-	3	50	50	100	4
6	PCC	MVJ19MAEL26	Structures Lab	AE	-	-	3	3	50	50	100	2
7	PCC	MVJ19MAE27	Technical Seminar	AE	-	-	2	-	100	-	100	2
				Total	15	10	5	18	400	300	700	24

Note: PCC: Professional Core Course, PEC: Professional Elective Course			
Professional Elective-I		**Professional Elective-II**	
Course Code **MVJ19MAE24X**	**Course Title**	**Course Code**	**Course Title** **MVJ19MAE25X**
MVJ19MAE241	Practical Finite Element Method	MVJ19MAE251	Theory of Combustion
MVJ19MAE242	Helicopter Dynamics	MVJ19MAE252	Unmanned Aerial Vehicles
MVJ19MAE243	Theory of Plates and Shells	MVJ19MAE253	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.

III SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course		Course Title	Teaching Department	Teaching hours/week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in Hours	CIE Marks	SEE Marks	Total marks	
	Type	Code			L	T	P					
1	PCC	MVJ19MAE31	Aircraft Flight Dynamics & Automatic Flight Control	AE	3	2	-	3	50	50	100	4
2	PEC	MVJ19MAE32	Professional Elective-III	AE	3	-	-	3	50	50	100	3
3	PEC	MVJ19MAE33	Professional Elective-IV	AE	3	-	-	3	50	50	100	3
4	PCC	MVJ19MAEP34	Minor Project	AE	-	-	3	3	50	50	100	2
5	PCC	MVJ19MAEP35	Major Project Phase-1	AE	-	-	3	3	100	-	100	2
6	PCC	MVJ19MAEI36	Internship	AE	-	-	2	3	50	50	100	7
				Total	9	2	8	18	350	250	600	21

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.

Note: PCC: Professional Core Course, PEC: Professional Elective Course			
Professional Elective-III		**Professional Elective-IV**	
Course Code MVJ19MAE32X	**Course Title**	**Course Code**	**Course Title MVJ19MAE33X**
MVJ19MAE321	Artificial Intelligence and Robotics	MVJ19MAE331	Hypersonic Aerodynamics
MVJ19MAE322	Flight Vehicle Design	MVJ19MAE332	Flight Testing
MVJ19MAE323	Theory of Aeroelasticity	MVJ19MAE333	Fatigue and Fracture Mechanics

Probability & Statistics-Prerequisite for the MVJ19MAE321Course

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

SEMESTER M.TECH- (Aeronautical Engineering)

S No	Course		Course Title	Teaching Department	Teaching hours/week			Examination				Credits
					Theory Lecture	Tutorial	Practical/ Drawing	Duration in Hours	CIE Marks	SEE Marks	Total marks	
	Type	Code			L	T	P					
1	PC	MVJ19MAEP41	Major Project Phase-2	AE	-	-	4	3	50	50	100	19
				Total	-	-	4	3	50	50	100	19

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	**MVJ19MAE11**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 50 : 10 : 0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course objective is to:

1. Use of Fourier series and its Application
2. Acquire Knowledge of principal of vectors Differentiation and integrals
3. Acquire knowledge of numerical solution to equations
4. Apply finite difference approximate in various forms.

Module-1	**L3&L4**	10Hrs.

Review of Fourier series and Applications, Review of Laplace Transforms and Applications. classification of second order linear partial differential equations, Canonical forms for hyperbolic, parabolic and elliptic equations, Homogeneous and Non Homogeneous equations with constant coefficients, Applications

Applications: Forced oscillation,Approximation by Trignomotric polynomials,Frequencies and damps dowm motionlessness

Video link ;https://www.khanacademy.org/
http://www.nptelvideos.in
https://www.classcentral.com/

Module-2	**L3&L4**	10Hrs.

Vector Functions, General rules for differentiation, Velocity and Acceleration, Gradient of a scalar field, Directional Derivative, Properties of Gradient, Divergence of vector point function, Curl of a vector point function, Properties of Divergence and Curl. Applications Integration of vector functions, Line integral, Circulation, Work done by a force, Surface integrals, Volume integrals, Divergence Theorem of Gauss, Green's Theorem in the plane, Stoke's Theorem, problems on all the three theorems and Applications

Applications: Vector Integration is widely used in Aeronautical Engineering -In studying surface ,area,Velocity,acceleration,Force,pressure.

Video link: http://15mat31svit.blogspot.com/2017/11/module-5-vector-integration-and.html
https://solitaryroad.com/c254.html

Module-3	**L3&L4**	10Hrs.

Review of Complex analysis, Complex analysis applied to potential theory, Electrostatic fields, conformal mapping, Heat problems, Fluid flow, General properties of Harmonic functions, Complex

Integration, Cauchy’s Theorem, Cauchy’s Integral Formula, Cauchy’s Integral Formula for Derivatives, Taylor’s and Laurent’s series. Applications. Singular point, Residue, Method of finding Resides, Residue Theorem, Contour Integration, Integration round the unit circle, Rectangular contour, Applications

Applications:.Applications to flow problems- complex potential, velocity potential, equipotential lines, stream functions, stream lines.

Video link : https://www.khanacademy.org/

http://www.nptelvideos.in/

https://www.classcentral.com/

Module-4	L3&L4	10Hrs.

Numerical Solutions algebraic and transcendental equations: False position method, Newton – Raphson method, Iteration method, Aitken’s method, Solution of linear simultaneous equations. Gauss elimination method, Inverse of a matrix , Gauss-Seidal method, Crout’s method. Solution of Ordinary Differential Equations: Taylor’s Series method, Picard’s method, Euler’s method, Euler’s Modified method, Runge-Kutta 4^{th}order method. Predictor and corrector method (Milen’s and Adams-Bashfourth) Applications

Applications: Steady state analysis, Spring Mass system,Equllibrium & Min Potential energy

Video link**: https://www.math.ust.hk/~machas/numerical-methods.pdf**

https://www.sciencedirect.com/topics/engineering/numerical-method

Module-5	L3&L4	10 Hrs.

Finite differences, Interpolation, Newton’s Forward & Backward Interpolation formulae, Lagrange’s formula, Newton’s Divided difference, Central difference formulae (all formulae with proof). Numerical Differentiation, Numerical Integration (all rules with proof). Applications

Applications: Experinental Data Analysis,Linear Regression & Population analysis,Computer work By Numerical Integration.

Video link : **https://www.math.ust.hk/~machas/numerical-methods.pdf**

https://www.sciencedirect.com/topics/engineering/numerical-method

https://www.khanacademy.org/

http://www.nptelvideos.in/

Course outcomes:	
CO1	Apply Fourier series and its Application
CO2	Evaluate Differential and integral.
CO3	Analyse numerical solution to equations
CO4	Determine finite difference approximate in various forms.
CO5	Apply Numerical solution and its Applications

Reference Books:	
1.	Erwin Kreyszing, Advanced Engineering Mathematics, John Wiley &Sons(Asia) Pvt. Ltd. 8th edition
2.	H K Dass, Advanced Engineering Mathematics, S Chand and Company Ltd. 12thedition.
3.	Bali and Iyengar,Engineering Mathematics, Laxmi Publications (P) Ltd. 6thedition
4.	C. Ray Wylie and Louis C Barret, Advanced Engineering, Mathematics Tata McGraw Hill Publishing Co. Ltd. 6th edition.
5	Michael D Greenberg, Advanced Engineering Mathematics, Pearsons India Ltd. 2nd edition.
6	B S Grewal, Higher Engineering Mathematics, 12th edition.

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

High-3, Medium-2, Low-1

Course Title	**AERODYNAMICS**	Semester	I
Course Code	**MVJ19MAE12**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course objective is to:

Module-1 Gain knowledge of incompressible flows over aerofoil	**RBT L3,L4**	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 Understand aerofoil and wing aerodynamic characteristics and theory of lift generation	**RBT L3,L4**	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 Learn about flow over aerofoils airfoils at subsonic, transonic and supersonic speeds	**RBT L3,L4**	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:** 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/101105023/		
Module-4 Acquire knowledge of compressible gas dynamics	**RBT L3,L4**	10 Hrs.
Compressible flow over airfoil: Full velocity potential equation. Small perturbationtheory. Linearized velocity potential equation and boundary conditions. Pressure coefficient for small perturbation. Prandtl- Glauret compressibility correction. Critical Mach number, Drag Divergence Mach Number, Sound barrier. Transonic area rule, supercritical airfoil, swept wing and delta wing. **Laboratory Sessions/ Experimental learning:** Estimation Compressible flow pressure distribution and thereby estimate Drag Divergence Mach number for the given aerofoil **Applications** Applicable in standard Airplane Design **Video link / Additional online information (related to module if any):** https://nptel.ac.in/courses/101105023/		
Module-5 Acquire knowledge of heat addition in a duct flows	**RBT L3,L4**	10 Hrs.
One dimensional flow through constant area duct: Fanno flow and Fanno line, Rayleigh flow and Rayleigh line. Method of characteristics and its application. Flow past Wedge and cone **Laboratory Sessions/ Experimental learning:** Estimation of compressible flow past a wedge and cone in a supersonic wind tunnel. **Applications** Applicable in standard Airplane Design or Ducted Engine design **Video link / Additional online information (related to module if any):** https://nptel.ac.in/courses/101105023/		

Course outcomes:	
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 problems with heat addition and removal through constant area ducts

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

5.	John D. Anderson, Modern compressible flow, McGraw-Hill publication.
6.	E L Houghton and P W Carpenter, Aerodynamics for Engineering students, Edward Arnold publication, 1993
7.	Yahya, S M., Fundamentals of compressible flow, Wiley Eastern. 1991
8.	Radhakrishnan E, Compressible Flows 1997

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	**INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS**	Semester	I
Course Code	**MVJ19MAE13**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	04	**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	**RBT Level**	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.	L3,L4	10
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	**RBT Level**	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.	L3,L4	10
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	**RBT Level**	Hrs.

Spacecraft Launch Vehicles: Rocket propulsion principles and types and propellants; 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.	L3,L4	10
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=lbuCMYy7AeI https://www.youtube.com/watch?v=JyaYF9tpEQw		
Module-4	**RBT Level**	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.	L3,L4	10
Laboratory Sessions/ Experimental learning: NA Applications: The test plan separates the application of the loads and environments as ... ground-handling 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	**RBT Level**	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	L3,L4	10
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=NQ-Hul5FgDY https://www.youtube.com/watch?v=E9fbEW9rnc0		

Course outcomes:	
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.
5.	Jane's, All The World Aircraft.
6	S K Khanna, M G Arora and S S Jain, Airport Planning and Design, NEM Chand and Brothers Roorki, 6th Edition, 2001.

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

High-3, Medium-2, Low-1

Course Title	**AEROSPACE PROPULSION**	Semester	I
Course Code	**MVJ19MAE14**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10: 10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3 Hrs.

Course objective is to:

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

Module-1	**L2,L3**	8 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 EngineSim Applet Version 1.8a (latest edition) by using Beginner's Guide to Propulsion https://www.grc.nasa.gov/WWW/K-12/airplane/ngnsim.html
2. Calculate and draw the performance curves using EngineSim 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-propulsion-systems-spring-2012/lecture-notes/MIT16_50S12_lec17.pdf
2. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems-spring-2012/lecture-notes/MIT16_50S12_lec18.pdf
3. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems-spring-2012/lecture-notes/MIT16_50S12_lec19.pdf
4. https://nptel.ac.in/courses/101106033/

Module-2	**L3,L4**	8 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 Propulsion https://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-propulsion-systems-spring-2012/lecture-notes/MIT16_50S12_lec16.pdf
2. https://nptel.ac.in/courses/101106033/
3. https://www.youtube.com/watch?v=OTdnvk-h3cE
4. https://youtu.be/rSN05n0t5mk

Module-3	L3,L4	8 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-propulsion-systems-spring-2012/lecture-notes/MIT16_50S12_lec9.pdf

2. https://nptel.ac.in/courses/101106033/
3. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsion-systems-spring-2012/lecture-notes/MIT16_50S12_lec13.pdf
4. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/lecture-notes/lecture_16.pdf
5. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/lecture-notes/lecture_17_18.pdf

Module-4	**L3,L4**	8 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
3. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/lecture-notes/lecture_21.pdf
4. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-512-rocket-propulsion-fall-2005/lecture-notes/lecture_24.pdf

Module-5	**L3,L4**	8 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 atypical space launch vehicle launch procedure.

Laboratory Sessions/ Experimental learning:

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

Applications: Aerospace industry

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

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

Course outcomes:

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

CO14.1	Explain the construction and working principle of various propulsion devices
CO14.2	Enumerate and suggest solution for gas turbine engine related problems
CO14.3	Solve chemical rocket combustion related problems
CO14.4	Estimate solid rocket burn rate and related parameters
CO14.5	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.
5.	Cohen, H. Rogers, and G. Rogers. "GFC and Saravanamuttoo, HIH “Gas Turbine Theory”." (1989).
6.	Cornelisse, Jacobus W., Herman FR Schöyer, and Karel F. Wakker. Rocket propulsion and spaceflight dynamics. Pitman Publishing, 1979.

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

High-3, Medium-2, Low-1

Course Title	**RESEARCH METHODOLOGY AND IPR**	Semester	I
Course Code	**MVJ19MAE15**	**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**	03 Hrs

Course objective is to: The Students are able to **1.** Study an overview of research methodology and explain techniques of defining a research problem **2.** Learn the functions of literature review in research and research design **3.** Describe the details of sampling designs, measurement and scaling techniques and also different methods of data collections. **4.** Illustrate several parametric tests of hypotheses and Chi-square test. **5.** Describe the art of interpretation and the art of writing research reports & IPR Acts.		
Module-1	**RBT Level**	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	L2,L3	05
Module-2	**RBT Level**	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 a conceptual framework, Writing about the literature reviewed. **Research Design**: Meaning of Research Design, Need for Research Design,	L2,L3	05

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	**RBT Level**	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/	L2,L3	05
Module-4	**RBT Level**	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 in making statistical decisions using experimental data. 2. Validate chi-square test by superposition theorem.	L2,L3	05

Applications: Accuracy in testing, statistical methods. Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=14PQawp_rjk https://nptel.ac.in/courses/103106120/		
Module-5	**RBT Level**	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/	L2,L3	05

Course outcomes: The Students are 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 International,4th Edition, 2018
2.	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.
3.	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
4.	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
CO1	3	2	1	1	2	2	1	1	1	1	1	2
CO2	3	2	1	1	2	2	1	1	1	1	1	2
CO3	3	2	2	2	2	2	1	1	1	1	1	1
CO4	3	2	2	2	2	2	1	1	1	1	1	1
CO5	3	2	2	1	2	2	1	1	1	1	1	2

High-3, Medium-2, Low-1

Course Title	**AERODYNAMIC LAB**	Semester	I
Course Code	**MVJ19MAEL16**	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 20 : 0 : 20	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	02	**Exam. Duration**	3 Hrs

Course objective is to:

Familiarization with various wind tunnel experimental facilities

Understand different sensors and measurement techniques and model set up system

Conduct the test, acquire the data and analyse and document

Laboratory Sessions

1. Calibration of test section of a subsonic wind tunnel.
2. Smoke flow visualization on a wing model at different angles of incidence at low speeds.
3. Tuft flow visualisation on a wing model at different angles of incidences at low speeds: Identify zones of attached and separated flows
4. Surface pressure distribution around building models in multiple model arrangement
5. Surface pressure distribution on a cambered wing at different angles of incidence and calculation of lift and pressure drag.
6. Calculation of total drag of a cambered airfoil at a low incidence using pitot-static probe wake survey
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.
8. Study the effect of Blockage ratio on drag & pressure distribution of a circular cylinder
9. Study of pressure distribution on hemi spherical objects.
10. Measurement of turbulence level in a low speed wind tunnel
11. Study of wake behind wing under a reverse flow condition at various angles of attack & compare it with normal flow conditions
12. Conduct a series of test to obtain the stagnation pressure response of pitot probe in a wind

tunnel for varied yaw angle and obtain the response curve in terms of error, (percentage of velocity head) to yaw angle.

13. To determine longitudinal static stability derivative of an aircraft configuration model at various angles of attack and side slips
14. To determine lateral and directional static stability derivative of an aircraft configuration model at various angles of attack and side slips

Course outcomes:

CO1	Demonstrate various experimental facilities
CO2	Explain the use of different sensors and measurement techniques
CO3	Perform the test, acquire the data and analyse and document
CO4	Study of wake behind wing under a reverse flow condition
CO5	Determine longitudinal static stability derivative.

Conduct of Practical Examination:

1.	All laboratory experiments are to be included for practical examination.
2.	Students are allowed to pick one experiment from the lot.
3.	Strictly follow the instructions as printed on the cover page of answer script for breakup of Marks.
4.	Change of experiment is allowed only once and marks allotted to the procedure part to be made zero.

CO-PO Mapping

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

High-3, Medium-2, Low-1

AIRCRAFT PROPULSION LABORATORY SEMESTER – I [As per Choice Based Credit System (CBCS) Scheme]			
Laboratory Code	**MVJ19MAEL17**	CIE	50
Number of Lecture Hours/Week	**01** Hr Tutorial (Instructions) **02** Hours Laboratory	SEE	50
RBT Level	L1, L2, L3	Credits	2

Course objectives: This course will enable students 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

1. Cascade testing of a model of turbine blade row and study of wake survey.
2. Estimation of propeller performance
3. Estimation of propeller performance
4. Forced Convective heat transfer on a flat surface
5. Measurement of Burning Velocity of a Premixed Flame
6. Investigation of relationship between flame speed and air-fuel ratio for a slow burning gaseous fuel.
7. Construction of flame stability diagram through flame lift up and flame fall back
8. Determination of heat of combustion of aviation fuels
9. Fuel - injection characteristics (spray cone geometry; spray speed etc. for various type of injectors)
10. Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through axial flow fan unit
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 .
12. Measurement of static overall pressure rise & rotor static pressure rise & fan overall efficiency through contra rotating axial flow fan unit
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.

14. Effect of inlet flow conditions on under-expanding /over-expanding nozzle.

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
CO4	Estimate the pressure distribution over airfoil and thrust generated.
CO5	Calculate the performance of the jet engine and fuel injection system

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

High-3, Medium-2, Low-1

Course Title	**AIRCRAFT PERFORMANCE&FLIGHT MECHANICS**	Semester	II
Course Code	**MVJ19MAE21**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course objective is to:		
Module-1 Understand the steady performance of airplanes	**RBT L3,L4**	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 Understand the accelerated performance of airplane	**RBT L3,L4**	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 Acquire knowledge of static longitudinal stability of airplane	**RBT L3,L4**	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 Acquire knowledge of static directional and lateral stability of airplane	RBT L3,L4	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 4

Module-5 Gain knowledge of dynamic longitudinal stability of airplanes	RBT L3,L4	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:	
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.
5.	Ojha S.K., Flight Performance of Aircraft, AIAA Education Series. Editor in Chief, J.S.Przemieniecki 1995.
6.	Bandu N. Pamadi, Performance Stability, Dynamics and Control of Airplanes, AIAA 2nd Edition Series, 2004.

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

High-3, Medium-2, Low-1

Course Title	**APPLIED COMPUTATIONAL FLUID DYNAMICS**	Semester	II
Course Code	**MVJ19MAE22**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10:10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course objective is to: This course will enable students to

1. Understand CFD ideas and Mathematical behavior of PDEs
2. Acquire the knowledge to solve CFD problems through finite difference discritisation
3. Gain knowledge for grid generation and optimize grids
4. Acquire the knowledge to solve CFD problems through finite volume technique

Module-1	**RBT Level**	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	L2,L3	12
Module-2	**RBT Level**	Hrs.
Discretization: Essence of discritization- 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	L3,L4	12
Module-3	**RBT Level**	Hrs.

Grid Generation: Structured Grid Generation:-Algebraic Methods, Numerical grid generation methods, Surface grid generation, Multi Block Structured grid generation. 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	L3,L4	12
Module-4	**RBT Level**	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	L3&L4	12
Module-5	**RBT Level**	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	L3&L4	12

Course outcomes:

CO1	Develop grids around given shapes and transform the physical domain in to computational

	domain
CO2	Develop adaptive structured and unstructured grids
CO3	Apply knowledge to solve CFD problems through finite difference and 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.

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

High-3, Medium-2, Low-1

Course Title	**AIRFRAME STRUCTURES AND STRUCTURAL DESIGN**	Semester	II
Course Code	**MVJ19MAE23**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	03

Course objective is to: This course will enable students 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	**L3,L4**	10Hrs.

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	**L3,L4**	10Hrs.

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	**L3**	10Hrs.
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	**L3,L4**	10Hrs.
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 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	**L3,L4**	10Hrs.
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:	
CO110.1	Apply fundamentals of structural analysis of airframe parts
CO110.2	Demonstrate knowledge of practical aircraft stress analysis.
CO110.3	Analyse Buckling and stability as applied to aircraft structures and design against fatigue

CO110.4	Demonstrate knowledge of Wing box structure and Fuselage.
CO110.5	Demonstrate knowledge of Empennage structure, Landing gear and engine mounts

Reference Books:	
1.	T.H.G. Megson, 'Aircraft structures for engineering students', fourth edition, Butterworth-Heinemann, 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
CO1	3	3	2	2	1	1	1	1	1	1	0	2
CO2	3	3	3	3	1	1	1	1	1	1	0	2
CO3	3	3	3	3	1	1	1	1	1	1	0	2
CO4	3	2	3	2	1	1	1	1	1	1	0	2
CO5	3	2	3	2	1	1	1	1	1	1	0	2

High-3, Medium-2, Low-1

Course Title	**PRACTICAL FINITE ELEMENT ANALYSIS**	Semester	**II**
Course Code	**MVJ19MAE241**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	

Course objective is to:

1. Understand the basic concepts of FEA and strength of materials.
2. Acquire the knowledge on Meshing and its types
3. Learn the static and dynamic analysis
4. Learn the Thermal, Fatigue, Crash & NVH Analysis.
5. Understand the concepts of Post Processing Techniques.

Module-1	RBT Level	Hrs.
Introduction to Finite Element Analysis: Methods to Solve any Engineering Problem, analytical or Numerical Problem, Brief Introduction to Different Numerical Methods, DOF, What is FEM, Advantages of FEA, Design Cycles, Absolute vs. Relative Design. History of Finite Element Method, Present, Theoretical Finite Element Analysis, Software Based FEM, Practical Applications of FEA, Failure Analysis, Future of FEA. **Basics of Statics and Strength of Materials**: Stress, Types of Stress, Types of Forces, Types of Moments, Material Properties and Boundary Conditions: E, G&U, Material Classification, Material Properties, Boundary Conditions, How to Apply Constraints. Laboratory Sessions/ Experimental learning: Ansys Lab Applications: Piece-wise approximation of physical fields on finite elements. Video link / Additional online information (related to module if any): Nptel Video: FEM by Dr. R. Krishnakumar, IIT Madras	L3, L4	12

Module-2	RBT Level	Hrs.
Introduction to Meshing: Need for Meshing, Types of Elements, Element Type, Element Length, Meshing Techniques, Meshing in Critical Areas, 1-D Meshing: Stiffness Matrix- Assembly of Two Rod Elements, Beam Element, Special Features of Beam Elements **2-D Meshing:** Family of 2-d Elements, Thin Shell Elements, Effect of Mesh Density in the Critical Region, Effect of Biasing in the Critical Region, Symmetric Boundary Conditions, Different Element Type, Options for Shell Meshing, Geometry Associative Mesh,. 3-D Meshing: When to Use 1-d,2-d,3-d Elements, DOFS for Solid Elements, Tetra Meshing Techniques, Quality	L3, L4	12

Checks for Tetra Meshing, Brick Meshing, Quality Checks for Brick Meshing, Checks for Meshing Laboratory Sessions/ Experimental learning: Ansys Lab Applications: Meshing reduces the degrees of freedom from infinite to finite. Video link / Additional online information (related to module if any): Nptel Video: Computer Aided design by Dr. Anoop Chawla, IIT Delhi.		
Module-3	**RBT Level**	Hrs.
Linear Static & Non-Linear Analysis: Definition, Design Modifications Based on Linear Static Analysis. Linear Static Solvers, Solution Restart Method, h-element vs. p-element, Sub-modelling, Linear Buckling Analysis. Comparison of Linear and Nonlinear FEA, Types of Nonlinearity, Stress-Strain Measures for Nonlinear Analysis, Solution Techniques for Nonlinear Analysis, Newton Raphson Method, Essential Steps to Start with Nonlinear FEA, **Dynamic Analysis**: Static Analysis vs. Dynamic Analysis, Difference Between Time Domain and Frequency Domain, Types of Loading, Simple Harmonic Motion, Free Vibration, Free - Free Run, How to Avoid Resonance, Damping Consideration, Forced Vibration, Single DOF System: Frequency Response Analysis, Transient Response Analysis, Dynamic Analysis Solvers, Two DOF System, Frequency Response Analysis Base Excitation, Bracket, Transient Response Analysis. Laboratory Sessions/ Experimental learning: Ansys Lab Applications: Static analysis is performed in a non-runtime environment, dynamic analysis adopts the opposite approach and is executed while a program is in operation.it performs continuous and concurrent risk assessments, searching for vulnerabilities within web applications and speeding interventions Video link / Additional online information (related to module if any): Nptel Video: Vibration of structures by Prof. A. Dasgupta, IIT Kharagpur.	L3, L4	12
Module-4	**RBT Level**	Hrs.
Thermal Analysis: Introduction, Conduction Heat Transfer, Steady State Conduction, Unsteady State Conduction, Convection Heat Transfer, Forced Convection (Internal Flow), Forced Convection (External Flow), Meshing for Thermal Analysis, Free/Natural Convection, Radiation Heat Transfer, Practical Application of Thermal Analysis. **Fatigue Analysis:** Why Fatigue Analysis, Static, Dynamic and Fatigue Analysis Comparison, what is Fatigue, History of Fatigue, Definitions, Various Approaches in Fatigue Analysis, Stress Life Approach, Strain Life Approach, Fracture Mechanics Approach, Cycle Counting, Multi-Axial Fatigue, CAE (Fatigue) and Test Data Correlation	L3, L4	12

Laboratory Sessions/ Experimental learning: Ansys Lab Applications: To understand the physical phenomenon either natural or man made and most important to control them. Video link / Additional online information (related to module if any): Nptel Video: FEM by Dr. R. Krishnakumar, IIT Madras.		
Module-5	**RBT Level**	Hrs.
Crash Analysis & NVH Analysis: Introduction, Structural Crash Worthiness, Transient Dynamics Solution Methodology, Explicit & Implicit Methods, Lagrangian and Eulerian Codes, Effect of Process and Residual Stress on Crash Analysis, Typical Application of Crash Worthiness Simulations in Various Industries, Introduction to NVH Concepts, Frequency Range of FE Dynamic Analysis, FEA for Structural Dynamics, FEA for Acoustics, Model Validation, Model Updating, Design Modification, Vibration and Noise Control. **Post Processing Techniques:** How to Validate & Check Accuracy of the Result, How to View Results, Average and Unaverage Stresses, Interpretation of Results and Design Modifications, CAE Reports, Experimental Validation and Data Acquisition, How to Measure Fatigue Life, How to Measure Natural Frequency Laboratory Sessions/ Experimental learning: Ansys Lab Applications: Virtual prototype concepts enable modelling of various problems relating to noise and vibration to a great detail.. Video link / Additional online information (related to module if any): Nptel Video: Accident analysis lecture 46 by IIT Kharagpur.	L3, L4	12

Course outcomes:

CO1	Describe the concepts of FEA and strength of materials.
CO2	Analyse Meshing and its types
CO3	Evaluate static and dynamic analysis
CO4	Evaluate Thermal, Fatigue, Crash & NVH Analysis.
CO5	Describe the concepts of Post Processing Techniques

Reference Books:

1.	Nitin S. Gokhale, Practical Finite Element Analysis, Finite to Infinite, 2008.
2.	G.R. Liu & S. S. Quek, Finite Element Method: A Practical Course, Butterworth-Heinemann, 2003
3.	Bryan J. Mac Donald, Practical Stress Analysis with Finite Elements, Glasnevin Publishing, 2007
4.	Practical Aspects of Finite Element Simulation, Altair’s Academic Program, 2015

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

High-3, Medium-2, Low-1

Course Title	**HELICOPTER DYNAMICS**	Semester	II
Course Code	**MVJ19MAE242**	**CIE**	50
Total No. of Contact Hours	60 L: T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3 Hrs

Course objective is to:

1. Comprehend the basic concepts of helicopter dynamics.
2. Acquire the knowledge of basic helicopter performance
3. Understand the Rotor Airfoil Aerodynamics
4. Gain knowledge on the Stability and Control of Helicopter
5. Learn about the standards, specifications and conceptual design of Helicopters

Module-1	L3,L4	8Hrs.

INRODUCTION

A history of helicopter flight; Fundamentals of Rotor Aerodynamics; Momentum theory analysis in hovering flight. Disk loading, power loading, thrust & power coefficients. Figure of merit, rotor solidity and blade loading coefficient. Power required in flight. Axial climb, descent, and autorotation. Blade Element Analysis: Blade element analysis in hovering and forward flight. Rotating blade motion. Types of rotors. Concept of blade flapping, lagging and coning angle. Equilibrium about the flapping hinge, and lead/lag hinge.

Laboratory Sessions/ Experimental learning: Estimation of propeller performance

Applications: Rotor Aerodynamics and rotor configuration
Video link / Additional online information (related to module if any):
https://nptel.ac.in/courses/101/104/101104017/

Module-2	L3,L4	8Hrs.

BASIC HELICOPTER PERFORMANCE

Hovering and axial climb performance. Forward flight performance; Induced power, blade profile power, parasite power, tail rotor power, climb power total power. Effects of gross weight, density and altitude. Speed for minimum power, maximum range. Factors affecting forward speed, and ground effect.

Laboratory Sessions/ Experimental learning: Study of wake behind wing under a reverse flow condition at various angles of attack & compare it with normal flow conditions

Applications: Performance of Helicopter and factors affecting its performance

Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104017/		
Module-3	L3	8Hrs.
ROTOR AIRFOIL AERODYNAMICS Rotor airfoil requirements, effects of Reynolds number and Mach number. Airfoil shape definition, Airfoil pressure distribution. Pitching moment. Maximum lift and stall characteristics, high angle of attack range. Rotor Wakes and Blade Tip Vortices: Flow visualization techniques, Characteristics of rotor wake in hover, and forward flight. Other characteristics of rotor wake. Structure of the tip vortices. Flow topology of dynamic stall. Laboratory Sessions/ Experimental learning: Smoke flow visualization on a wing model at different angles of incidence at low speeds Applications: Aerodynamics of Airfoils and its characteristic features Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104017/		
Module-4	L3,L4	8Hrs.
HELICOPTER FLIGHT DYNAMICS Forward speed disturbance, vertical speed disturbance, pitching angular velocity disturbance, side-slip disturbance, yawing disturbance. Static stability of helicopters: longitudinal, lateral-directional. Dynamic stability aspects. Main rotor and tail rotor control. Laboratory Sessions/ Experimental learning: To determine longitudinal static stability derivative of an aircraft configuration model at various angles of attack and side slips Applications: Helicopter stability & control Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/101/104/101104062/		
Module-5	L3,L4	8Hrs.
STANDARDS, SPECIFICATIONS & TESTING ASPECTS Scope of requirements. General and operational requirements. Military derivatives of civil rotorcraft. Structural strength and design for operation on specified surfaces. Rotorcraft vibration classification. Flight and Ground Handling Qualities-General requirements and definitions. Control characteristics, beak forces. Levels of handling qualities. Flight Testing- General handing flight test requirements and, basis of limitations. Conceptual Design of Helicopters: Overall design requirements .Design of main rotors, Fuselage design, Empennage design, Design of tail rotors, High speed rotorcraft Laboratory Sessions/ Experimental learning: Surface pressure distribution on a cambered wing at different angles of incidence and calculation of lift and pressure drag. Applications: Helicopter standards, its regulations involved and design requirements		

Video link / Additional online information (related to module if any):
https://nptel.ac.in/courses/101/104/101104069/

Course outcomes:	
CO1	Apply the basic concepts of Helicopter Dynamics and Analysis of Blade Element
CO2	Understand the basic Helicopter Performance and the factors affecting its performance characteristics
CO3	Understand the aerodynamics of Rotor Airfoil and acquire knowledge of Rotor wake and Blade tip vortices
CO4	Acquire knowledge of Stability and Control of Helicopter
CO5	Acquire knowledge of the Design of Helicopters and its Standards and Specifications

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

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

High-3, Medium-2, Low-1

Course Title	**THEORY OF PLATES AND SHELLS**	Semester	2^{nd}
Course Code	**MVJ19MAE243**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	04	**Exam. Duration**	3hours

Course objective is to:

1. Understand the stresses developed in plates under bending
2. Learn the stresses developed in plates under buckling
3. Learn the stresses developed in shells under bending
4. Acquire the knowledge of the stresses developed in shells under buckling

Module-1	RBT Level	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 3. Matlab coding https://www.youtube.com/watch?v=cwRoevN67fs&feature=emb_logo	L3	12
Module-2	**RBT Level**	**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.	L3	12

<table>
<tr><td>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
2. Transformation of tensors
https://www.youtube.com/watch?v=qaOzuDTQVBU&feature=emb_logo</td><td></td><td></td></tr>
<tr><td>Module-3</td><td>RBT Level</td><td>Hrs.</td></tr>
<tr><td>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 ansys
2. 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</td><td>L3,L4</td><td>12</td></tr>
</table>

2. Governing equations of a plate https://www.youtube.com/watch?v=-rv3jOHe7RY&feature=emb_logo		
Module-4	**RBT Level**	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 ansys 2. 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 stiffness https://www.youtube.com/watch?v=QTHrs8nqo18&feature=emb_logo 2. Navier solution https://www.youtube.com/watch?v=yNMfqsoSLEw&feature=emb_logo	L3,L4	12
Module-5	**RBT Level**	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 3. Vertical containers	L3,L4	12

Video link / Additional online information: 1. Levy solution https://www.youtube.com/watch?v=ipTErjTeCmY&feature=emb_logo 2. Buckling of plates https://www.youtube.com/watch?v=S11B2-qaWPc&feature=emb_logo		

Course outcomes: The student shall 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, McGraw-Hill 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
CO1	3	3	2	1	-	1	1	1	1	1	-	1
CO2	3	3	2	1	1	1	1	1	1	1	-	1
CO3	3	3	2	1	1	1	1	1	1	1	-	1
CO4	3	3	2	1	-	1	1	1	1	1	-	1
CO5	3	3	2	1	-	1	1	1	1	1	-	1

High-3, Medium-2, Low-1

Course Title	**THEORY OF COMBUSTION**	Semester	II
Course Code	**MVJ19MAE251**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 50 : 10: 0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course Objective is to: 1. Understand basic combustion theory 2. Acquire knowledge of diffusion flame **3.** Know the combustion process in engines		
Module-1	**RBT Level**	Hrs.
Basics of Combustion theory: Combustion Stochiometry and Thermo chemical Calculation, Chemical Kinetics and Equilibrium, Transport Phenomena-Theory of Viscosity, conductivity and diffusivity. **Laboratory Sessions/ Experimental learning :** To determine the kinematic viscosity using Torsion viscosmeter To determine the kinematic viscosity using Redwood viscosmeter To determine the stoichiometric Air/Fuel ratio for selective gases like CO, H_2, CH_4, C_2H_2, C_2H_6, C_3H_8, Natural gas. **Applications:** 1. In light machinery thin oils (for example, lubricant oil used in clocks) with low viscosity is used. 2. In heavy machinery, highly viscous oils (example: grease) are used. 3. In lubrication, viscosity is the most significant characteristic of lubricating oils. 4. It is also very vital in greases. **Video link / Additional online information (related to module if any) :** https://www.youtube.com/watch?v=Ts4LtHD1IvI https://sagemetering.com/applications/energy/natural-gas-flow-meter-for-conservat https://pubs.acs.org/doi/suppl/10.1021/ed200506d/suppl_file/ed200506d_si_002.doc https://www.youtube.com/watch?v=FJi4ODPQSE0	L2,L3,L4	10
Module-2	**RBT Level**	Hrs.
Pre-Mixed Flames: Description of premixed flames, Burning velocity and parametric dependences, Experimental methods of measuring burning velocity,	L3.L4	10

Simple one-dimensional thermal theory of flame, concepts of minimum ignition energy, quenching distance, stability limits and flame stabilization. Turbulent premixed flame. **Laboratory Sessions/ Experimental learning :** To determine experimentally, the burning velocity measurement of natural gas. **Applications :** Burning velocity determines the performance of the vehicle **Video link / Additional online information (related to module if any) :** https://www.youtube.com/watch?v=ATab44UxN48 https://www.youtube.com/watch?v=hB7yHvxPYPY https://www.youtube.com/watch?v=ibmEZo_0Ad4		
Module-3	**RBT Level**	Hrs.
Diffusion Flame: Jet flame physical description, theoretical analysis-Burke-Schumann's analysis, mechanism of soot formation, Difference between premixed and diffusion flames, Liquid fuel combustion, Difference between premixed and diffusion flames, Liquid fuel combustion, Difference between premixed and diffusion flames, Liquid fuel combustion- Conservation equations, calculation of mass burning rate, Droplet burning time, Droplet combustion in convective environment. **Laboratory Sessions/ Experimental learning :** 1. To determine the large-scale burning rates of pool fire for liquid fuel from small-scale flammability tests performed in a Tewarson Calorimeter Apparatus. **Applications :** 1. Liquid fuel combustion in Petrol and Diesel engines. 2. Bipropellant liquid rockets generally use a liquid fuel, such as liquid hydrogen or a hydrocarbon fuel such as RP-1, and a liquid oxidizer, such as liquid oxygen. 3. Jet fuel is a colorless, combustible, straight-run petroleum distillate liquid. Its principal uses are as jet engine fuel. The most common jet fuel worldwide is a kerosene-based fuel classified as JET A-1. **Video link / Additional online information (related to module if any) :** https://www.youtube.com/watch?v=_gqO3ncLfRg https://www.youtube.com/watch?v=77ME6rzwarE	L3,L4	10
Module-4	**RBT Level**	Hrs.

Combustion in Reciprocating and Gas- Turbine Engines: Description of the combustion process in piston engines, Combustion efficiency and factors affecting it, Rankine-Hugoniot curves, Deflagration and Detonation in reciprocating engines and preventive methods. Description of different types of combustion chambers in gas-turbine engines, primary requirements of the combustor, Flow structure, recirculation and flame stabilization in main combustion chamber, afterburners. **Laboratory Sessions/ Experimental learning :** 1. Combustion in different types of combustion chambers and determining its efficiency. 2. Flame stabilization in the combustion chamber **Applications :** 1. Combustion in Reciprocating and Gas Turbine Engines 2. Combustion in piston engines and to determine the combustion efficiency. **Video link / Additional online information (related to module if any) :** https://www.youtube.com/watch?v=uuXwN1dBoV4 https://www.youtube.com/watch?v=9rieabf_Jnk https://www.youtube.com/watch?v=zcWkEKNvqCA	L3	10
Module-5	**RBT Level**	Hrs.
Combustion in Rocket Engines and Emission: Types of Rockets based on combustion, Solid fuel combustion, combustion of carbon particle-simplified analysis, boundary layer combustion, combustion of carbon sphere with CO burning gas phase. Chemical Emission from combustion and its effects, Exhaust gas analysis, Emission control methods. **Laboratory Sessions/ Experimental learning :** To determine the calorific value of the solid fuel through Bomb Calorimeter. **Applications :** Mostly they are rocket applications which solid fuels consisting both fuel and oxidizer in the solid. **Video link / Additional online information (related to module if any) :** https://www.youtube.com/watch?v=xfs-9DqgNXI https://www.youtube.com/watch?v=Sk7XyAoVUmk https://www.youtube.com/watch?v=H4AOjbgwkxY https://www.youtube.com/watch?v=598ZSwm8Ie0 https://www.youtube.com/watch?v=V6VPJA2jg7s https://www.youtube.com/watch?v=QQB1Iw3zJbc' https://www.youtube.com/watch?v=6l8D6DsRDYk https://www.youtube.com/watch?v=sZWBEOTQdtU	**L3 & L4**	10

Course outcomes:	
CO1	Apply basic combustion theory
CO2	Solve Problems related diffusion flame.
CO3	Describe combustion process in engine.

Reference Books:	
1.	Charles E. Baukal, Industrial Combustion,CRC,2012
2.	Fundamentals of combustion, D P Mishra, PHI Publication,2007
3.	G. Singer Combustion, Fossil Power Systems, 4th Ed. 1993 Ed Pub.

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

High-3, Medium-2, Low-1

Course Title	**UNMANNED AERIAL VEHICLES**	Semester	II
Course Code	**MVJ19MAE252**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 50 : 10 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	04	**Exam. Duration**	3 Hrs

Course objective is to:

1. Comprehend the basic aviation history and UAV systems
2. Acquire the knowledge of basic aerodynamics, performance, stability and control of UAVs
3. Understand the propulsive aspects, and loads and structures.

Module-1	**RBT Level**	Hrs.
Introduction: Aviation History and Overview of UAV systems, Classes and Missions of UAVs, Definitions and Terminology, UAV fundamentals , Examples of UAV systems-very small , small, Medium and Large UAV.	L2,L3	12
Laboratory Sessions/ Experimental learning: Demo in UAV lab Applications: Mapping of Landslide Affected Area, Infested Crop Damage Assessment, monitoring activities Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=_CRYi34uuYY		
Module-2	**RBT Level**	Hrs.
The Air Vehicle Basic Aerodynamics: Basic Aerodynamics equations, Aircraft polar, the real wing and Airplane, Induced drag, the boundary layer, Flapping wings, Total Air-Vehicle Drag Performance: Overview, Climbing flight, Range and Endurance – for propeller driven aircraft, range- a jet-driven aircraft, Guiding Flight	L3,L4	12
Laboratory Sessions/ Experimental learning: Demo in the Aerodynamics lab Applications: Aerodynamic forces in fluid flow, though common applications include fixed-wing or rotary-wing aircraft, wind turbines and propellers, ground and marine vehicles, internal flows Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=X1gEXs_gna4 https://www.youtube.com/watch?v=5ltjFEei3AI		
Module-3	**RBT Level**	Hrs.
Stability and Control: Overview, Stability, longitudinal, lateral, dynamic stability, Aerodynamics control, pitch control, lateral control, Autopilots, sensor, controller, actuator, airframe control, inner and outer loops, Flight-Control Classification, Overall Modes of Operation, Sensors Supporting the Autopilot	L3,L4	12
Laboratory Sessions/ Experimental learning:NA		

Applications: Aircraft designer must ensure that a pilot can reasonably control the aircraft Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=mGG_LVO5Tis https://www.youtube.com/watch?v=WhQ8Ai4fa_Q		
Module-4	**RBT Level**	Hrs.
Propulsion: Overview, Thrust Generation, Powered Lift, Sources of Power, The Two-Cycle Engine, The Rotary Engine, The Gas Turbine, Electric Motors, Sources of Electrical Power. Loads and Structures Loads, Dynamic Loads, Materials, Sandwich Construction, Skin or Reinforcing Materials, Resin Materials, Core Materials, Construction Techniques.	L3,L4	12
Laboratory Sessions/ Experimental learning: Applications: Gas turbines are used to power aircraft, trains, ships, electrical generators. Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=BUn5-0VG3Hw		
Module-5	**RBT Level**	Hrs.
Mission Planning and Control, Air Vehicle and Payload Control, Reconnaissance/Surveillance Payloads, Weapon Payloads, Other Payloads, Data-Link Functions and Attributes, Data-Link Margin, Data-Rate Reduction, Launch Systems, Recovery Systems, Launch and Recovery Trade-offs	L3,L4	12
Laboratory Sessions/ Experimental learning:NA Applications: Deployment and recovery of ROV's, AUV's, Subsea Drills used in the Offshore Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=Fgw1w4Roij0 https://www.youtube.com/watch?v=tfVIrJmScUw		

Course outcomes:	
CO1	Apply the basic concepts of UAV systems.
CO2	Explain the basic of aerodynamics and Performance.
CO3	Apply the stability and control required for UAV.
CO4	Analyse the propulsion loads and structures for the UAV.
CO5	Apply the knowledge to mission planning and control and data-link functions.

Reference Books:	
1.	Paul Gerin Fahlstrom , Thomas James Gleason, Introduction to UAV Systems, 4th Edition, Wiley Publication, 2012
2.	Landen Rosen, Unmanned Aerial Vehicle, Alpha Editions , ISBN13 : 9789385505034
3.	Unmanned Aerial Vehicles: DOD‟s Acquisition Efforts, Publisher : Alpha Editions, ISBN13 : 9781297017544

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

High-3, Medium-2, Low-1

Course Title	**COMPOSITE MATERIALS AND FABRICATION TECHNIQUES**	Semester	II
Course Code	**MVJ19MAE253**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 50 : 0 : 10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course objective is to:

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

Module-1	RBT Level	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/	L3, L4	12
Module-2	**RBT Level**	**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/	L3, L4	12
Module-3	**RBT Level**	**Hrs.**
Fabrication of Composite Structures: Cutting, machining, drilling, mechanical fasteners and adhesive bonding, joining, computer-aided design and manufacturing, tooling, fabrication equipment.	L3, L4	12

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/ https://www.youtube.com/watch?v=VMH6qbED7pg		
Module-4	**RBT Level**	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/	L3, L4	12
Module-5	**RBT Level**	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/mechanical-engineering/ManufacturingOfComposites-IIT-Kanpur/lecture-17.html	L3, L4	12

Course outcomes:

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 R M Jones, “ Mechanics of Composite Materials”, McGraw-Hill, New York, 1975

2.	Meing Schwaitz, Composite materials hand book, McGraw Hill Book Company. 1984
3.	John Wenbag, Composite Materials Fabrication`, Wolfgang Publications, 21 April 2011
4.	Forming Metal handbook, 9th edition, ASM handbook, V15. 1988, P327 338.
5.	Artar Kaw, Mechanics of composites by CRC Press. 2002.

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

High-3, Medium-2, Low-1

Course Title	**STRUCTURES LAB**	Semester	II
Course Code	MVJ9MAEL26	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 00 : 00 : 40	**SEE**	50
No. of Contact Hours/week	03	**Total**	100
Credits	2	**Exam. Duration**	03 Hrs

Course objective is to: The Students are able to

1. Familiarize with various structural experiment facilities
2. Familiarize with different structural experiments
3. Conduct the test acquire the data and analyse
4. Determine the shear flow in different sections
5. Understand the vibration analysis of the structural members

List of Experiments

1. Determine the Bending Modulus of sandwich Beam
2. Tensile, compressive and flexural testing of a composite material part.
3. Determination of natural frequency and mode shapes of a cantilever beam for the following cases.
   a. Constant cross section
   b. Varying cross section
   c. Constant cross section and varying stiffness
4. Determining of Shear centre through shear flow measurement for following cases.
   a. Close section – Symmetrical bending
   b. Open section – Unsymmetrical bending
5. Determine the index factor `K` in a tensile filed of Wagner Beam Structural Modelling of a 3-D Wing.
6. Structural Modelling of fuselage bulk head of an aircraft.
7. Determine the Shear flow analysis under defined load conditions on a spar of 3D wing.
8. Determine the Shear flow analysis under defined load conditions in a bulkhead.
9. Estimation of shear flow in a plate of varying stiffness under bending and torsion.
10. Free and forced vibration analysis of a structural frame.
11. Analysis of active vibration control in a smart material part.
12. Experimental determination of behaviour of a composite beam subjected to combined loading.

Course outcomes: The Students are able to

CO1	Demonstrate various experiment facilities
CO2	Explain the use of different measurement techniques

CO3	Perform the test, acquire the data, analyse and document
CO4	Estimate the shear flow in different sections
CO5	Analyse the vibration analysis of structural members

Conduct of Practical Examination:	
1	All laboratory experiments are to be included for practical examination.
2	Students are allowed to pick one experiment from the lot
3	Strictly follow the instructions as printed on the cover page of answer script for breakup of Marks.
4	Change of experiment is allowed only once and Marks allotted to the procedure part to be made zero.

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

High-3, Medium-2, Low-1

Course Title	**AIRCRAFT FLIGHT DYNAMICS & AUTOMATIC FLIGHT CONTROL**	Semester	III
Course Code	**MVJ19MAE31**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10:10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	4	**Exam. Duration**	3hrs

Course objective is to: This course will enable students 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	**RBT Level**	**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, 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	L3,L4	10
Module-2	**RBT Level**	**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	L3,L4	10
Module-3	**RBT Level**	**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	L3,L4	10

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	**RBT Level**	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	L3, L4	10
Module-5	**RBT Level**	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	L3, L4	10

Course outcomes:

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

CO5	Apply automatic flight control for pitch, roll and yaw motions
CO4	Evaluate feedback 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
CO1	3	3	2	3	0	0	0	0	0	0	1	0
CO2	3	2	2	3	0	0	0	0	0	0	0	1
CO3	2	3	2	3	0	0	0	0	0	0	1	0
CO4	3	2	3	3	0	0	0	0	0	0	0	0
CO5	3	2	2	2	0	0	0	0	0	0	2	1

High-3, Medium-2, Low-1

Course Title	**ARTIFICAL INTELLIGENCE AND ROBOTICS**	Semester	III
Course Code	**MVJ19MAE321**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to: This course will enable students to

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

Module-1	RBT Level	Hrs.

Introduction & Propositional Logic: History of AI, Propositional logicComputability & 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/	L2,L3	10
Module – 2	**RBT Level**	**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	L3,L4	10

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	**RBT Level**	**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/	L3,L4	10
Module – 4	**RBT Level**	**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/	L3,L4	10
Module – 5	**RBT Level**	**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/	L3,L4	10

Course outcomes:

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

Reference Books:

1	Wolfgang Ertel, Introduction to Artificial Intelligence, Springer, 2017.
2	Appu Kuttan K.K., Robotics, I K International Publishing House, Pvt. Ltd. 2012
3	Vinod Chandra S.S., and Anand Hareendran 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
CO1	3	3	2	3	3	0	1	0	0	0	0	0
CO2	3	3	2	3	3	0	1	0	0	0	0	0
CO3	3	3	3	2	1	0	3	0	0	0	0	0
CO4	3	3	3	2	1	0	3	0	0	0	0	0
CO5	2	3	3	1	3	0	1	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	**FLIGHT VEHICLE DESIGN**	Semester	
Course Code	**MVJ19MAE322**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3Hrs

Course objective is to: : This course will enable students to

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

Module-1	**RBT Level**	Hrs.
Overview of Design Process Introduction, Requirements, Standards and Specifications, 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/ **2.** https://nptel.ac.in/courses/101/106/101106035/	L3,L4	10 Hours
Module-2	**RBT Level**	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.	L3,L4	10 Hours

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	**RBT Level**	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/	L3	10 Hours
Module-4	**RBT Level**	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/ 2.https://nptel.ac.in/courses/101104062/#	L3,L4	10 Hours
Module-5	**RBT Level**	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	L3,L4	
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/101108047/lec29.pdf		10 Hours

Course outcomes:

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
CO1	3	2	2	2	0	0	0	0	0	0	0	0
CO2	3	3	2	2	0	0	0	0	0	0	0	0
CO3	3	3	3	3	0	0	0	0	0	0	0	0
CO4	3	3	3	3	0	0	0	0	0	0	0	0
CO5	3	3	3	2	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	**THEORY OF AERO ELASTICITY**	Semester	III
Course Code	**MVJ19MAE323**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10:10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to: This course will enable students 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	RBT Level	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	L3,L4	10
Module-2	**RBT Level**	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:	L3,L4	10

1.Mach divergence 2.Flutter Analsys Video links: https://nptel.ac.in/courses/101104005/		
Module-3	**RBT Level**	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 Between Theodorsen, Wagner and Quasi-steady approximation for 2D Applications: 1. Selection of optimal approximation based on the condition 2. Analyze the airspeed at different $\frac{x}{c}$ location Video links: https://nptel.ac.in/courses/101104005/	L3,L4	10
Module-4	**RBT Level**	Hrs.
Test model similarities: Dimensional concepts. Vibration model similarity laws. Dimensionless form of equation of motion. Mode shapes and natural frequencies in dimensionless forms. Model scale factors. Flutter model similarity law. Scale factors. Structural simulation:-shape, mass and stiffness. Laboratory Session/Experimental Learning: Study of wingtip washout using flat wing varying stiffness Applications: 1. load distribution 2. Position of Aerodynamic center 3. Design consideration to reduce wingtip stall Video links: https://nptel.ac.in/courses/101104005/	L3 , L4	10
Module-5	**RBT Level**	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	L3 ,L4	10
2. First mode: Wing bending 3. Third mode: Aileron deflection Video links: https://nptel.ac.in/courses/101104005/		

Course outcomes:	
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.
5.	Bisplinghoff, R. and Ashley, H., Principles of Aeroelasticity, Dover, 1962.

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	**HYPERSONIC AERODYNAMICS**	Semester	III
Course Code	**MVJ19MAE331**	**CIE**	50

Total No. of Contact Hours	60 L : T : P :: 50:10:0	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to: This course will enable students to

1. Understand basic theory of hypersonic flight
2. Acquire knowledge of viscous effects in high speed aerodynamics
3. Gain knowledge of hypersonic test requirements

<table>
<tr><th>Module-1</th><th>RBT Level</th><th>Hrs.</th></tr>
<tr><td>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 hypersonic flow 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 Mach 5 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
https://www.youtube.com/watch?v=gEXPVuAPyb0
https://www.youtube.com/watch?v=LJUjFe_2AUw&list=PLf_lu4AHS69DvXx9qbtFvpuwtoxBvPvns
https://www.youtube.com/watch?v=C4W-FDPy0Fg&list=PLf_lu4AHS69DvXx9qbtFvpuwtoxBvPvns&index=3
https://www.youtube.com/watch?v=vL1qAfS0gic
https://nptel.ac.in/content/storage2/courses/101103003/pdf/mod7.pdf
https://link.springer.com/chapter/10.1007/978-1-4612-0379-7_3</td><td>L3 and L4</td><td>10</td></tr>
</table>

https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101105024/lec36.pdf https://freevideolectures.com/course/3265/high-speed-aero-dynamics		
Module-2	**RBT Level**	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 reentry. **Video link / Additional online information (related to module if any) :** https://m.youtube.com/watch?v=He0yMe6aZoc https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101105024/lec36.pdf https://freevideolectures.com/course/3265/high-speed-aero-dynamics	L3 and L4	10
Module-3	**RBT Level**	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 *reentry vehicles*), orbital (e.g., the Soyuz), or unbounded (e.g., meteors) trajectories. Various advanced technologies have been developed to enable atmospheric *reentry* and flight at extreme velocities. 3. Study of objects entering an atmosphere from space at high velocities relative to the atmosphere will cause very high levels of heating. **Video link / Additional online information (related to module if any) :**	L3 and L4	10

https://www.youtube.com/watch?v=rPks77igQ0I https://www.youtube.com/watch?v=Jb4prVsXkZU https://www.youtube.com/watch?v=XRz9clQYN5M https://m.youtube.com/watch?v=RChlt5wdqBs https://m.youtube.com/watch?v=VAQBXw6cVdE https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101105024/lec36.pdf https://freevideolectures.com/course/3265/high-speed-aero-dynamics		
Module-4	**RBT Level**	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. **Video link / Additional online information (related to module if any) :** https://m.youtube.com/watch?v=916u-pQc-_8 https://m.youtube.com/watch?v=6wWYKQirmJ4 https://m.youtube.com/watch?v=quD-BF19usw https://m.youtube.com/watch?v=sN_8IQTf-YQ https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101105024/lec36.pdf https://freevideolectures.com/course/3265/high-speed-aero-dynamics	L3 and L4	10
Module-5	**RBT Level**	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=NXP3VZ7ldyg https://m.youtube.com/watch?v=KMly0DVpQO8	L3 & L4	10
https://m.youtube.com/watch?v=08ykxNNJccE#searching https://nptel.ac.in/content/storage2/nptel_data3/html/mhrd/ict/text/101105024/lec36.pdf https://freevideolectures.com/course/3265/high-speed-aero-dynamics		

Course outcomes:

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
CO1	3	3	2	1	1	0	0	0	1	0	0	0
CO2	3	3	2	1	1	0	0	0	1	0	0	0
CO3	3	3	2	1	1	0	0	0	1	0	0	0

High-3, Medium-2, Low-1

Course Title	**FLIGHT TESTING**	Semester	III
Course Code	**MVJ19MAE332**	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10:10	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3hrs

Course objective is to: This course will enable students to

- Understand the Concept of flight testing and requirement of flight test instrumentation
- Acquire knowledge of flight test techniques
- Acquire the knowledge of handling qualities

Module-1	**RBT Level**	Hrs.

Introduction: Sequence, Planning and governing regulations of flight testing. Aircraft weight and center of gravity, flight testing tolerances. Various Flight test Method, Method of reducing data uncertainty in flight test data -sources and magnitudes of error, avoiding and minimizing errors. Flight test instrumentation: Planning flight test instrumentation, selection of flight test, Measurement of flight parameters. Onboard and ground based data acquisition system. Radio telemetry. Laboratory Session/Experimental Learning: Flight instrument response using Matlab Applications: 1. Calibration of flight instruments 2. Measurement of flight parameters 3. Pilot View	L2, L3	10
Module-2	**RBT Level**	Hrs.
Performance flight testing - range, endurance and climb: Airspeed – in flight calibration. Level flight performance for propeller driven aircraft and for Jet aircraft - Techniques and data reduction. Estimation of range, endurance and climb performance. Performance flight testing -take-off, landing, Contribution of various factors on Climb performance, Environment effect on climb performance. Turning flight: Maneuvering performance estimation. Environment effect on maneuvering performance. Take-off and landing methods, procedures and data reduction. Laboratory Session/Experimental Learning: Takeoff and landing distance with loading factor and velocity Applications: 1. landing distance with environmental conditions	L3, L4	10

2. takeoff distance with environmental conditions 3. effect of weight on Landing and takeoff distance 4. Runway Requirement Video link: https://youtu.be/tEWuP1NVdgE?list=PLtUPB3SCffXP43al7ILIR5qaZF_5fEDXm		
Module-3	**RBT Level**	Hrs.

Stability and control - longitudinal and maneuvering: Static & dynamic longitudinal stability: -methods of flight testing and data reduction techniques. Maneuvering stability methods & data reduction. Stability and control - lateral & directional: Lateral and directional static & dynamic stability:-Coupling between rolling and yawing moments. Definition of Roll stability. Adverse yaw effects. Aileron reversal. Regulations, test techniques and method of data reduction. Laboratory Session/Experimental Learning: Calculating stability derivatives for stability and control using Matlab Applications: 1. controllability of the aircraft 2. Stability analysis at various conditions 3. Design appropriate Autopilot Video link: https://youtu.be/9GNVZi35xZg?list=PLtUPB3SCffXPbKOXpvNMi6YI_tUqfFv82	L3	10
Module-4	**RBT Level**	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. Laboratory Session/Experimental Learning: Calculating stability derivatives for stability and control using Matlab Applications: 1. control requirement of the aircraft 2. Stability analysis at various conditions 3. Design appropriate Autopilot Video link: https://youtu.be/nHPAVy35Wrs?list=PLtUPB3SCffXPbKOXpvNMi6YI_tUqfFv82	L3,L4	10
Module-5	**RBT Level**	Hrs.

Flying qualities: MIL and FAR regulations. Cooper-Harper scale. Pilot Rating. Flight test procedures. Hazardous flight testing: Stall and spin- regulations, test and recovery techniques. Test techniques for flutter, vibration and buffeting. Handling qualities during emergency conditions. Laboratory Session/Experimental Learning: Calculating vibration on the aircraft wing using ANSYS Applications: 1. Flutter Analysis 2. Acoustic Analysis Video Link: https://youtu.be/bGA_Hr85IQg	L3,L4	10

Course outcomes:

CO1	Apply the Concept of flight testing and planning of flight testing
CO2	Specify the requirement of flight test instrumentation
CO3	Estimate aircraft performance and stability from flight test data
CO4	Evaluate handling qualities from flight test data
CO5	Flight test during emergency or inoperative conditions

Reference Books:

1.	Ralph D Kimberlin, Flight Testing of Fixed Wing Aircraft, AIAA educational Series,2003.
2.	Perkins, C.D., Hege R.E, Airplane performance, stability and control, John Wiley & sons inc, New York, 1988.
3.	AGARD, Flight Test Manual Vol. I to IV

CO-PO Mapping

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

CO5	3	2	2	2	0	0	0	0	0	0	2	1

High-3, Medium-2, Low-1

Course Title	**FATIGUE AND FRACTURE MECHANICS**	Semester	III
Course Code	MVJ19MAE333	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	4	**Total**	100
Credits	3	**Exam. Duration**	3 Hours

Course objective is to: This course will enable students to

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

Module-1	RBT Level	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-mechanics.html https://swayam.gov.in/nd1_noc19_me42/preview https://www.springer.com/gp/book/9783030292409	**L3&L4**	10
Module-2	**RBT Level**	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 https://onlinelibrary.wiley.com/doi/full/10.1111/ffe.12487 https://www.springer.com/gp/book/9780412129919	**L3&L4**	10
Module-3	**RBT Level**	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/ https://nptel.ac.in/courses/113107078/ https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29EM.1943-7889.0001607	**L3&L4**	10
Module-4	**RBT Level**	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):	**L3&L4**	10

https://nptel.ac.in/courses/112106065/ https://nptel.ac.in/courses/113107078/ https://www.youtube.com/watch?v=OlexdbPETPw https://www.youtube.com/watch?v=mndOapHRUAQ https://www.intechopen.com/books/applied-fracture-mechanics/good-practicefor-fatigue-crack-growth-curves-description https://onlinelibrary.wiley.com/doi/book/10.1002/9781118013373		
Module-5	**RBT Level**	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/ https://nptel.ac.in/courses/113107078/ https://nptel.ac.in/courses/113106070/ https://www.springer.com/gp/book/9789400725942 https://onlinelibrary.wiley.com/doi/abs/10.1111/ffe.12912	**L3&L4**	10

Course outcomes:

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 Artinus Nijhoff, Elementary Engineering Fracture of Mechanics-, London 1999.

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

High-3, Medium-2, Low-1