Course Title	**COMPLEX VARIABLES AND NUMERICAL METHODS**	Semester	IV
Course Code	**MVJ19MAE41 /MAS41/MME41**	**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 Hrs

Course objective is to: This course will enable students to

•Understand the concepts of Complex variables and transformation for solving Engineering Problems.

•Understand the concepts of complex integration, Poles and Residuals in the stability analysis of engineering problems.

•Apply the concept to find extremal of functionals.

•Solve initial value problems using appropriate numerical methods.

•Students learn to obtain solution s of ordinary and partial differential equations numerically.

Module-1	**RBT Level**	Hrs.
Complex variables - 1: Functions of complex variables, Analytic function, Cauchy-Riemann Equations in Cartesian and polar coordinates, Consequences of CauchyRiemann Equations, Construction of analytic functions (Using MilneThomson method) . **Transformations:** Bilinear Transformation, Conformal transformation, Discussion of the transformations $w= z^2$, $w=e^z$ and $w= z+ \_^{a}z$,$(z \neq 0)$. **Web Link and Video Lectures:** 1. https://www.khanacademy.org/ 2. http://www.nptelvideos.in/ 3. https://www.classcentral.com/	L2,L3,L4	10
Module-2	**RBT Level**	Hrs.
Complex variables-2:	L2,L3,L4	10

Complex integration - Cauchy theorem, Cauchy's Integral TheoremProblems, Taylor & Laurent series- Problems, Singularities, Types of Singularities, Poles, Residues-definitions, Cauchy residue theorem - Problems. **Web Link and Video Lectures:** 1. https://www.khanacademy.org/ 2. http://www.nptelvideos.in/ 3. https://www.classcentral.com/		
Module-3	**RBT Level**	Hrs.
Numerical methods-1: Numerical solution of Ordinary Differential Equations of first order and first degree, Taylor's series method, Modified Euler's method, Runge-Kutta method of fourth order, Milne's and Adam Bashforth Predictor and Corrector method. **Web Link and Video Lectures:** 1. https://www.khanacademy.org/ 2. http://www.nptelvideos.in/ 3. https://www.classcentral.com/	L2,L3	10
Module-4	**RBT Level**	Hrs.
Numerical methods-2: Numerical solution of Ordinary Differential Equations of second order: Runge-Kutta method of fourth order, Milne's Predictor and Corrector method. **Calculus of variations:** Variation of function and Functional, variational problems, Euler's equation, Geodesics and hanging chain problem. **Web Link and Video Lectures:** 1. https://www.khanacademy.org/ 2. http://www.nptelvideos.in/ 3. https://www.classcentral.com/	L2,L3	10
Module-5	**RBT Level**	Hrs.
Numerical methods-3: Numerical solution of Partial Differential Equations: Introduction, Finite difference approximations to derivatives, Numerical Solution of Laplace	L2,L3	10

Equation, Numerical solution of one-dimensional heat equation by Bendre - Schmidt's method and by Crank-Nicholson Method. Numerical solution of one-dimensional wave equation. **Web Link and Video Lectures:** 1. https://www.khanacademy.org/ 2. http://www.nptelvideos.in/ 3. https://www.classcentral.com/		

Course outcomes:	
CO1	State and prove Cauchy - Riemann equation with its consequences and demonstrate Conformal Transformation.
CO2	Illustrate Complex Integration using Cauchy's Integral theorem, Cauchy's Integral formula and Cauchy's Residue theorem.
CO3	Identify appropriate numerical methods to solve ODE.
CO4	Determine the extremals of functionals and solve the simple problems of the calculus of variations.
CO5	Choose appropriate numerical methods to solve Partial Differential Equations.

Reference Books:	
1.	B.S. Grewal, "Higher Engineering Mathematics" Khanna Publishers, 43rd Edition, 2013.
2.	Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley-India publishers, 10th edition,2014.
3	Ramana B. V., "Higher Engineering Mathematics", Tata Mc Graw-Hill, 2006.
4	Bali N. P. & Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 8th Edition.
5	Jain R. K. & Iyengar S.R.K., Advanced Engineering Mathematics, Narosa Publishing House, 2002.

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	1
CO2	3	3	0	3	0	0	0	0	0	0	1	0
CO3	3	2	0	2	0	0	0	0	0	0	0	0
CO4	3	3	0	3	0	0	0	0	0	0	0	1
CO5	3	3	0	3	0	0	0	0	0	0	1	0

High-3, Medium-2, Low-1

Course Title	**INCOMPRESSIBLE AERODYNAMICS**	Semester	IV
Course Code	**MVJ19AE42/AS42**	**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**	3Hrs

Course objective is to:

1. Understand the basics of fluid mechanics as a prerequisite to Aerodynamics
2. Acquire knowledge on typical airfoil characteristics and two-dimensional flows over airfoil
3. Acquire knowledge of incompressible flows over airfoil
4. Understand the fundamentals of incompressible flow over finite wings
5. Assimilate the understanding of application of finite wing theory and high lift systems

Module-1	L1, L2	10Hrs.

Review of Basic Fluid Mechanics

Continuity, momentum and energy equation, Control volume approach to Continuity, momentum and energy equation, Types of flow, pathlines, streamlines, and streaklines, units and dimensions, inviscid and viscous flows, compressibility, Mach number regimes. Vorticity, Angular velocity, Stream function, velocity potential function, Circulation, Numericals, Mach cone and Mach angle, Speed of sound.

Laboratory Sessions/ Experimental learning: Smoke flow visualization studies on a two dimensional airfoil at different angles of incidence at low speeds

Applications: provides a proper understanding of the flow properties and their characteristics features which helps in the study of flow over airfoils

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

Module-2	L1, L2	10Hrs.

Airfoil Characteristics

Fundamental aerodynamic variables, Airfoil nomenclature, airfoil characteristics. wing planform geometry, aerodynamic forces and moments, centre of pressure, pressure coefficient, aerodynamic center, calculation of airfoil lift and drag from measured surface pressure distributions, typical airfoil aerodynamic characteristics at low speeds. Types of drag-Definitions.

Laboratory Sessions/ Experimental learning: Smoke flow visualization studies on a two-dimensional circular cylinder at low speeds

Applications: understand the characteristics and the distribution of pressure over the airfoil Video link / Additional online information (related to module if any):
https://nptel.ac.in/courses/101105059/

Module-3	L1, L2,L3	10Hrs.

Two Dimensional Flows & Incompressible Flow Over Airfoil

Uniform flow, Source flow, Sink flow, Combination of a uniform flow with source and sink. Doublet flow. Non-lifting flow over a circular cylinder. Vortex flow. Lifting flow over a circular cylinder. Kutta-Joukowski theorem and generation of Lift, D'Alembert's paradox, Numericals, **Incompressible flow over airfoils:** Kelvin's circulation theorem and the starting vortex, vortex sheet, Kutta condition, Classical thin airfoil theory for symmetric and cambered airfoils. KuttaJoukowski theorem. and generation of Lift, Numerical.

Laboratory Sessions/ Experimental learning: Calculation of total drag of a two-dimensional circular cylinder at low speeds using pitot-static probe wake survey.

Applications: study the lifting and non lifting flows over cylinders and arbitrary bodies and understanding the theory behind lift generation

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

Module-4	L1, L2,L3	10Hrs.

Incompressible Flow Over Finite Wings

Biot-Savart law and Helmholtz's theorems, Vortex filament: Infinite and semi-infinite vortex filament, Induced velocity. Prandtl's classical lifting line theory:Downwash and induced drag. Elliptical and modified elliptical lift distribution.Lift distribution on wings. Limitations of Prandtl's lifting line theory. Extended lifting line theory-lifting surface theory, vortex lattice method for wings. Lift, drag and moment characteristics of complete airplane

Laboratory Sessions/ Experimental learning: Surface pressure distributions on a two-dimensional cambered airfoil at different angles of incidence and calculation of lift and pressure drag.

Applications: understanding the theory of lift generation over finite wings and their flow patterns

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

http://web.iaa.ncku.edu.tw/~aeromems/Aerodynamics/Ch5.pdf

Module-5	L1, L2,L3	10Hrs.

Applications of Finite Wing Theory & High Lift Systems

Simplified horse-shoe vortex model, influence of downwash on tail plane, ground effects. Swept wings: Introduction to sweep effects, swept wings, pressure coefficient, and typical aerodynamic characteristics. Introduction to high-lift systems, flaps, leading-edge slats and typical high – lift characteristics. Effects of thickness, camber and aspect ratio of wings, tip effects. Introduction to Source panel & vortex lattice method

Laboratory Sessions/ Experimental learning: Calculation of aerodynamic coefficients forces acting on a model aircraft using force balance at various angles of incidence, speed.

Applications: study the typical aerodynamics characteristics of swept wings and different types of high lift devices

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

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

Course outcomes:	
CO1	Describe the fundamental equations of continuity, momentum & energy of fluid flow.
CO2	Evaluate typical airfoil characteristics and two-dimensional flows over airfoil
CO3	Analyze the incompressible flow over airfoil
CO4	Compute and analyze the incompressible flow over finite wings
CO5	Apply finite wing theory and analyze high lift systems

Reference Books:	
1.	Anderson J.D, Fundamental of Aerodynamics, 5th edition, McGraw-Hill International Edition, New York **(**2011), ISBN-13: 978-0073398105.

2.	E. L. Houghton, P.W. Carpenter, Aerodynamics for Engineering Students, 5th edition, Elsevier, New York. (2010), ISBN-13: 978-0080966328
3.	Clancy L. J., Aerodynamics, Sterling book house, New Delhi. (2006), ISBN 13: 9780582988804
4.	Louis M. Milne-Thomson, Theoretical Aerodynamics, Imported Edition, Dover Publications, USA (2011), ISBN 9780486619804.

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	0	1	1	0	1	1	0	11
CO2	3	3	2	3	0	1	1	0	1	1	0	1
CO3	3	3	3	3	1	1	1	0	1	1	0	1
CO4	3	3	3	3	1	1	1	0	1	1	0	1
CO5	3	3	3	2	1	1	1	0	1	1	0	1

High-3, Medium-2, Low-1

Course Title	**FUNDAMENTALS OF AIRCRAFT STRUCTURES**	Semester	IV
Course Code	**MVJ19AE43**	**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 Hrs

Course objective is to: The Students are able to

1. Comprehend the basic concepts of stress strain and understand the different failure theories and to learn the concept of static strength
2. Illustrate the methods to design a structure against impact and fatigue loads.
3. Acquire the knowledge of types of loads on aerospace vehicles.
4. Understand the theory of elasticity.
5. Apply different Energy methods in calculations related to structural components and to understand the different methods to analyse columns

Module-1	**RBT Level**	Hrs.

Design for Static Strength: Introduction: Normal, shear, biaxial and tri-axial stresses, Stress tensor, Principal Stresses, Stress Analysis, Design considerations, Codes and Standards. Static Strength: Static loads and factor of safety, Theories of failure: Maximum normal stress theory, Maximum shear stress theory, Maximum strain theory, Strain energy theory, and Distortion energy theory, failure of brittle and ductile materials, Stress concentration, and Determination of Stress concentration factor. Laboratory Sessions/ Experimental learning: 1. Determination of Stress concentration factor for static load. 2. Determine the strain in x-y-z directions using strain gauge for a given beam Applications: Stress Analysis, Theory of failures Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=NnvImUMfYyc	L1, L2, L3	10 Hrs
Module-2	**RBT Level**	Hrs.
Design for Impact and Fatigue Strength: Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Introduction, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage. Laboratory Sessions/ Experimental learning: 1. Determine the notch sensitivity and impact toughness of engineering materials**.** 2. Demonstrate how fatigue tests are conducted and how to interpret results Applications: Fatigue Testing, Combined Loading	L1, L2, L3	10 Hrs

Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=ZsIwEp574ho https://www.youtube.com/watch?v=X-_qUQ3xaTA		
Module-3	**RBT Level**	Hrs.

Loads on Aircraft and Spacecrafts: Structural nomenclature, Types of loads, load factor, Aerodynamic loads, Symmetric manoeuvre loads, Velocity diagram, Function of structural components. **Spacecraft Structures:** Statically Determinate and Indeterminate structures, Analysis of plane truss, Method of joints, 3D Truss, Plane frames, Composite beam, Clapeyron's Three Moment Equation. Laboratory Sessions/ Experimental learning: 1. Determination of Deflection in a beam by applying point load and combined loading. 2. Determine the deflection of composite beam Applications: Analysis of Loads, Determinate and Indeterminate structures. Video link / Additional online information (related to module if any): https://nptel.ac.in/courses/105105166/ https://www.youtube.com/watch?v=q0_piF4-eNc	L1, L2, L3	10 Hrs
Module-4	**RBT Level**	Hrs.
Theory of Elasticity: Theory of Elasticity: Concept of stress and strain, derivation of Equilibrium equations, strain displacement relation, compatibility conditions and boundary conditions. Plane stress and Plane strain problems in 2D elasticity. Principle Stresses and Orientation of Principle Directions. **Columns**: Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, southwell plot, Beam-column. Laboratory Sessions/ Experimental learning: 1. Determine the Spring Stiffness for the given spring. 2. Buckling load of slender Eccentric Columns and Construction of Southwell Plot Applications: Stress and Strain displacement, Columns Video link / Additional online information (related to module if any): http://www.digimat.in/nptel/courses/video/112101095/L02.html https://www.digimat.in/nptel/courses/video/105105177/L01.html	L1, L2, L3	10Hrs
Module-5	**RBT Level**	Hrs.
Energy Methods: Strain Energy due to axial, bending and Torsional loads. Castigliano's theorem, Maxwell's Reciprocal theorem. **Introduction to Shear Flow:** Symmetrical and Unsymmetrical bending,	L1, L2, L3	10Hrs

Concept of shear flow – The shear centre and its determination – Shear flow distribution in symmetrical and unsymmetrical thin-walled sections. Laboratory Sessions/ Experimental learning: 1. Verify Maxwell's Reciprocal theorem 2. Determining of Shear centre location for open sections-unsymmetrical bending Applications: Maxwell's Theorem, Shear Flow and Shear Center Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=149j7Ys0F58 http://www.nptelvideos.com/video.php?id=1637		

Course outcomes: The Students are able to	
CO1	Apply the different failure theories to understand the concept of static strength.
CO2	Design a structure against fatigue loads and to design a material for impact load.
CO3	Analyze various loads experienced by an aircraft in flight and to understand the usage of different materials.
CO4	Assess compatibility conditions and boundary conditions to find the stress and strain of an elastic material.
CO5	Formulate different Energy methods in calculations related to structural components and to understand the different methods to analyse columns.

Reference Books:	
1.	Megson, T.H.G., "*Aircraft Structures for Engineering Students"*, Edward Arnold, 6th Edition 2017, Elsevier Aerospace Engineering series, ISBN-13: 978-0081009147, ISBN10: 9780081009147.
2.	Bruhn E.F., "*Analysis and Design of Flight Vehicles Structures"*, Tri-State offset Co.USA,1985
3.	Bruce K Donaldson, "*Analysis of Aircraft structures",* Cambridge Aerospace Series, reprint 2012, ISBN- 9780511801631
4.	Peery, D.J., and Azar, J.J., "Aircraft Structures", McGraw, Hill, N.Y, 2nd edition, 1993

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	0	1	1	0	1
CO2	3	2	2	1	1	1	1	1	1	1	0	1
CO3	3	2	2	1	1	1	1	0	1	1	0	1
CO4	3	2	2	1	1	1	1	0	1	1	0	1
CO5	3	2	2	1	1	1	1	1	1	1	0	1

High-3, Medium-2, Low-1

Course Title	**AIRCRAFT PROPULSION**	Semester	IV
Course Code	**MVJ19AE44**	**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 Hrs

Course objective is to:

This course will enable students 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 subsonic and supersonic inlets.
4. Describe the working of combustion chambers and nozzles.
5. Understand the fundamentals of rocket propulsion.

Module,1	**L1,L2,L3**	10 Hrs

Introduction: Review of thermodynamic principles, Principles of aircraft propulsion, Types of power plants, Working principles of internal combustion engine, Two stroke and four stroke piston engines, Gas, turbine engines, Cycle analysis of reciprocating engines and jet engines , advantages and disadvantages, numerical problems

Laboratory Sessions/ Experimental learning:

1. Identify and demonstrate the various components of Guiberson T-1020 (9 cylinder radial engine) and Tumansky R-25-300 R-26(Jet engine)

Applications: Automobile industries , Gas turbine industries and Power plants **Video link / Additional online information (related to module if any):**

1. https://youtu.be/XKcRf2R5h4o
2. https://youtu.be/fTAUq6G9apg
3. https://ocw.mit.edu/courses/mechanical-engineering/2-61-internal-combustion-enginesspring-2017/lecture-notes/MIT2_61S17_lec1.pdf
4. https://nptel.ac.in/courses/101106033/

Module,2	**L1,L2,L3,L4**	10 Hrs

Propeller Theories & Jet propulsion

Propeller Theories & Jet propulsion: Types of propeller, Propeller thrust: momentum theory, Blade element theories, propeller blade design, and propeller selection.

Jet Propulsion: Illustration of working of gas turbine engine , The thrust equation , Factors affecting

thrust , Effect of pressure, velocity and temperature changes of air entering compressor , Methods of thrust augmentation , Characteristics of turboprop, turbofan and turbojet , Performance characteristics. Ramjet and Scramjet Engines.

Laboratory Sessions/ Experimental learning:

1. Analyze the performance of a 2 blade fixed pick propeller and plot the performance

Applications: Gas turbine and aircraft engine design industries

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

1. https://youtu.be/0bP2MH3LqvI
2. https://youtu.be/KjiUUJdPGX0
3. https://youtu.be/vq54Tn9djsY
4. https://youtu.be/p1TqwAKwMuM
5. https://youtu.be/0jvTfgh4-Bc
6. https://youtu.be/uZ-76AytLMI

Module,3	**L1,L2,L3**	10 Hrs

Inlets

Subsonic Inlets

Internal flow and Stall in Subsonic inlets, Boundary layer separation. Major features of external flow near a subsonic inlet. Relation between minimum area ratio and external deceleration ratio.

Diffuser performance.

Supersonic inlets: Supersonic inlets, starting problem in supersonic inlets, Shock swallowing by area variation, External deceleration. Modes of inlet operation.

Laboratory Sessions/ Experimental learning:

1. Visualize the external and internal deceleration (pre compression and diffusion) over inlet using wind tunnel
2. 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
3. Calculate and draw the performance curves using EngineSim Applet Version 1.8a

Applications: gas turbine engine design industries

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

4. https://youtu.be/ZoObIZfLa94
5. https://youtu.be/hFO_n44Uv_Y

Module,4	**L1,L2,L3**	10 Hrs

Combustion chambers & Nozzles

Combustion chambers

Classification of combustion chambers, important factors affecting combustion chamber design, Combustion process, Combustion chamber performance Effect of operating variables on performance , Flame tube cooling , Flame stabilization , Use of flame holders

Nozzles: Theory of flow in isentropic nozzles, Convergent nozzles and nozzle choking, Nozzle throat conditions. Nozzle efficiency, Losses in nozzles. Over,expanded and under,expanded nozzles, Ejector and variable area nozzles, Thrust reversal.

Laboratory Sessions/ Experimental learning:

1. Make a model and explain thrust reversal technique
2. 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
3. Calculate and understand the aircraft motion and performance using Range Games Version 1.3

Applications: Gas turbine industries

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

4. https://youtu.be/3u7d-IlvRqs
5. https://youtu.be/LPXLFY-WR-4
6. https://youtu.be/E4wFJCHEwW4
7. https://youtu.be/nvDoiHQXXJk
8. https://youtu.be/bmLJq5aPBqc
9. https://youtu.be/eZ0C0H8Kj7k
10. https://youtu.be/pmepKkQ6I9w

Module,5	**L1,L2**	10 Hrs

Rocket Propulsion

Classification of rockets, Principle of rocket propulsion, Analysis of ideal chemical rocket, The chemical rocket, Solid propellant rockets, Liquid propellant rockets, Hybrid rockets, Cryogenic rockets nuclear propulsion, Electrodynamic propulsion, Photon propulsion, Propulsive efficiency.

Laboratory Sessions/ Experimental learning:

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

Applications: Rockets and missile manufacturing industries

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

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsionsystems-spring-2012/lecture-notes/MIT16_50S12_lec9.pdf
2. https://nptel.ac.in/courses/101106033/

3. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-50-introduction-to-propulsionsystems-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

Course outcomes:

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

CO211.1	Apply the basic thermodynamic principles and theories in aircraft propulsion.
CO211.2	Understand the thrust generation and performance of turbojets, turbofans and turboprops.
CO211.3	Analyze the performance of inlet for subsonic and supersonic applications
CO211.4	Demonstrate the principle of combustion and distinguish between different types of combustion chambers
CO211.5	Explain the basic principles of rocket propulsion.

Reference Books:

1.	Bhaskar Roy, Aircraft propulsion, Elsevier (2011), ISBN,13: 9788131214213
2.	V. Ganesan, Gas Turbines, Tata McGraw,Hill, 2010, New Delhi, India, ISBN: 0070681929.
3.	Hill, Philip G., and Carl R. Peterson. "Mechanics and Thermodynamics of Propulsion, 0201146592." (2010).
4.	Cohen, H. Rogers, G.F.C. and Saravanamuttoo, H.I.H., Gas Turbine Theory, Longman, 1989, ISBN 13: 9780582236325.

CO,PO Mapping

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

High,3, Medium,2, Low,1

CO4	3	3	2	1	0	0	0	0	0	0	0	0
CO5	3	3	2	0	0	0	0	0	0	0	0	0

High-3, Medium-2, Low-1

Course Title	**TURBOMACHINES**	Semester	IV
Course Code	**MVJ19AE45/AS45**	**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:

- Understand the basics of turbomachines
- Understanding the concept of energy transfer taking place in turbomachines
- Acquire the knowledge on design of centrifugal and axial compressors
- Acquire the knowledge on design of centrifugal and axial turbines
- Assimilate the understanding of hydraulic pumps and turbines

Module-1	**RBT Level**	Hrs.
Introduction to turbomachines: Classification and parts of a turbo machines; comparison with positive displacement machines; dimensionless parameters and their physical significance; specific speed; illustrative examples on dimensional analysis and model studies. **Energy transfer in turbomachines:** Basic Euler turbine equation and its alternate form; components of energy transfer; general expression for degree of reaction; construction of velocity triangles for different values of degree of reaction. **Laboratory Sessions/ Experimental learning:** Aircraft propulsion lab for acquiring knowledge of Gas turbine engine. **Applications**: Study of Turbomachines, components of gas turbine engines. **Video link / Additional online information:** https://nptel.ac.in/courses/112/106/112106200/	L1, L2	10
Module-2	**RBT Level**	Hrs.
General analysis of Turbomachines **Axial flow machines**-general analysis, degree of reaction, velocity triangles, diagram efficiency, maximum utilization factor for different R values, Numerical Problems	L1, L2, L3, L4	10

Radial flow machines –general analysis, Expression for degree of reaction, velocity triangles, Effect of blade discharge angle on energy transfer and degree of reaction, Effect of blade discharge angle on performance. **Laboratory Sessions/ Experimental learning**: Aircraft Propulsion lab and Fluid Mechanics lab for compressor and turbines. **Applications**: Compressors and Turbines in Aircraft engines. **Video link / Additional online information**: https://nptel.ac.in/courses/101/101/101101058/ https://www.youtube.com/watch?v=oitC03G-QYE		
Module-3	**RBT Level**	Hrs.
Compression process: Overall isentropic efficiency of compression; stage efficiency; comparison and relation between overall efficiency and stage efficiency; polytropic efficiency; preheat factor. **Expansion process:** Over all isentropic efficiency for a turbine; stage efficiency for a turbine; comparison and relation between stage efficiency and overall efficiency, polytropic efficiency; reheat factor for expansion process. **Laboratory Sessions/ Experimental learning**: Fluid Mechanics lab for compressor and turbines and Aircraft propulsion lab: Study of gas turbine turbojet engine **Applications:** Turbojet, turbofan, turbo shaft engines. **Video link / Additional online information**: https://youtu.be/8y5KX4kzt0A	L1, L2, L3, L4	10
Module-4	**RBT Level**	Hrs.
Design and performance analysis of Centrifugal compressors: Types, design parameters ,flow analysis in impeller blades, volutes and diffusers, losses, slip factor, characteristic curves, surging, choking. Construction details. **Design and performance analysis of axial fans and compressors:** Stage velocity diagrams, enthalpy-entropy diagrams, stage losses and efficiency, work done, simple stage design problems, performance characteristics, instability in axial compressors. Construction details. **Laboratory Sessions/ Experimental learning**: Aircraft propulsion lab: Study of gas turbine turbojet engine **Applications:** Turbojet, turbofan, turbo shaft engines. **Video link / Additional online information**: http://www.infocobuild.com/education/audio-video-courses/aeronautics-and-astronautics/TurbomachineryAerodynamics-IIT-Bombay/lecture-31.html https://www.youtube.com/watch?v=3bhoVSI6VoI https://www.youtube.com/watch?v=b1dyUVA19kQ	L1, L2, L3, L4	10
Module-5	**RBT Level**	Hrs.
Design and performance analysis of axial flow turbines: Turbine stage, work done, degree of reaction, losses and efficiency, flow passage; subsonic, transonic and supersonic turbines, multi-staging of turbine; exit flow conditions; turbine cooling **Design and performance analysis of radial turbines:**	L1, L2, L3, L4, L5	10

Thermodynamics and aerodynamics of radial turbines; radial turbine characteristics; losses and efficiency; design of radial turbine. **Laboratory Sessions/ Experimental learning**: Aircraft propulsion lab and Fluid mechanics lab. **Applications:** Turbojet, turbofan, turbo shaft engines. **Video link / Additional online information**: http://www.infocobuild.com/education/audio-video-courses/aeronautics-and-astronautics/TurbomachineryAerodynamics-IIT-Bombay/lecture-22.html **https://www.youtube.com/watch?v=h4LYyUOtQow**		

Course outcomes:

CO1	Compute the energy transfer and energy transformation in turbomachines.
CO2	Analyse the design of turbomachine blades.
CO3	Apply hydraulic pumps and turbines for specific requirements
CO4	Apply dimensionless parameters for turbomachines
CO5	Analyse Compression and Expansion process

Reference Books:

1.	S.M. Yahya, Turbines, Compressors & Fans, Tata-McGraw Hill Co., 2nd Edition (2002), ISBN 13: 9780070707023.
2.	D.G. Shephered, Principles of Turbo Machinery, The Macmillan Company (1964), ISBN-13: 978-0024096609.
3.	V. Kadambi and Manohar Prasad, An introduction to Energy conversion, Volume III, Turbo machinery, Wiley Eastern Ltd, 1977, ISBN: 9780852264539

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	**MECHANICS OF MACHINE THEORY**	Semester	IV
Course Code	**MVJ19AE46/AS46**	**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:

- Understand the theory of mechanisms including velocity, acceleration and static force analysis.
- Acquire knowledge of spur gears, gear train, balancing of rotating and reciprocating masses.
- Understand the concept of governors and gyroscope.

Module-1	**RBT Level**	Hrs.
Introduction to Mechanisms: Types of constrained motion, Link and its types, joints and its types, kinematic pair and its types, degrees of freedom, Grubler's criterion, Types of kinematic chains and inversions: Inversions of Four bar chain: Beam engine, coupling rod of a locomotive, Watt's indicator mechanism. Inversions of Single Slider Crank Chain: Pendulum pump or Bull engine, Oscillating cylinder engine, Rotary internal combustion engine, Crank and slotted lever quick return motion mechanism, Whitworth quick return motion mechanism. Inversions of Double Slider Crank Chain: Elliptical trammels, Scotch yoke mechanism, Oldham's coupling. Straight line motion mechanisms: Peaucellier's mechanism and Robert's mechanism. Intermittent Motion mechanisms: Geneva wheel mechanism and Ratchet and Pawl mechanism, Ackerman steering gear mechanism. Laboratory Sessions/ Experimental learning: Whitworth quick return motion mechanism. (Machine Shop) Applications: Ackerman steering gear mechanism. Video link / Additional online information: https://www.youtube.com/watch?v=g8uqeru2LQw	L1,L2	10
Module-2	**RBT Level**	Hrs.

Velocity, Acceleration and static force analysis of Mechanisms (Graphical Methods): Velocity and acceleration analysis of Four Bar mechanism, slider crank mechanism and Simple Mechanisms by vector polygons. Static force analysis: Introduction: Static equilibrium, Equilibrium of two and three force members. Members with two forces and torque. Free body diagrams, principle of virtual work. Static force analysis of four bar mechanism and slider-crank mechanism with and without friction Video link / Additional online information: https://www.youtube.com/watch?v=CTcdQzH5e04	L1,L2 & L3, L4	10

Module-3	**RBT Level**	Hrs.
Spur Gears and Gear Trains Spur Gears: Gear terminology, law of gearing, Path of contact, Arc of contact, Contact ratio of spur gear, Interference in involute gears, Methods of avoiding interference. Gear Trains: Simple gear trains, Compound gear trains, Reverted gear trains, Epicyclic gear trains, Analysis of epicyclic gear train (Algebraic and tabular methods), torques in epicyclic trains. Applications: Design Of spur Gear Video link / Additional online information: https://www.youtube.com/watch?v=N0hTFnvIE7A	L1,L2 & L3, L4	10
Module-4	**RBT Level**	Hrs.
Balancing of Rotating and Reciprocating Masses Balancing of Rotating Masses: Balancing of Several Masses Rotating in the Same Plane, Balancing of Several Masses Rotating in Different Planes (only Graphical Methods). Balancing of Reciprocating Masses: Primary and Secondary Unbalanced Forces of Reciprocating Masses, Partial Balancing of Unbalanced Primary Force in a Reciprocating Engine, Balancing of Primary and secondary Forces of Multi-cylinder In-line Engines, Balancing of Radial Engines (only Graphical Methods)	L1,L2 & L3, L4	10
Module-5	**RBT Level**	Hrs.

Governors and Gyroscope Governors: Types of governors; force analysis of Porter and Hartnell governors, Controlling force, stability, sensitiveness, isochronism, effort and power of Porter and Hartnell governors. Gyroscopes: Vectorial representation of angular motion, gyroscopic couple, effect of gyroscopic couple on plane disc and aeroplane Laboratory Sessions/ Experimental learning: Porter and Hartnell governors (Design lab) Applications:: Working Of Governors Links https://www.youtube.com/watch?v=FydJu1A1oeM	L1,L2 & L3, L4	10

Course outcomes:	
CO212.1	Apply the theory of velocity, acceleration and static force analysis to design of mechanisms.
CO212.2	Analyze static and dynamic force analysis of mechanisms.
CO212.3	Design of spur gears & Gear train.
CO212.4.	Evaluate spur gears, gear train, balancing of rotating and reciprocating masses.
CO212.5	Analyse governors and gyroscope

Reference Books:	
1	Rattan S.S, "Theory of Machines", Tata McGraw-Hill Publishing Company Ltd., New Delhi, and 3rd edition -2009, ISBN: 007014477X, 9780070144774.
2	J.J. Uicker, G.R. Pennock, J.E. Shigley. "Theory of Machines & Mechanisms", OXFORD 3rd Ed. 2009, ISBN-13: 978-0195371239
3	R. S. Khurmi, J.K. Gupta, "Theory of Machines", Eurasia Publishing House, 2008, ISBN 13: 9788121925242.
4	Robert L Norton, "Design of Machinery" by McGraw Hill, 2001, ISBN-13: 9780077421717.
5	Ambekar, "Mechanism and Machine theory", PHI Learning Pvt. Ltd., 2007, ISBN 13: 978812033134

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

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

High-3, Medium-2, Low-1

Course Title	**MATERIAL TESTING LAB**	Semester	IV
Course Code	**MVJ19AEL47A**	**CIE**	50
Total No. of Contact Hours	42 L : T : P :: 0 : 0 : 42	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	2	**Exam. Duration**	3hrs

Course objective is to:

1. Understand the relations among materials and their properties.
2. Comprehend the formation, properties and significance of the alloys through different experiments.
3. Acquire the practical knowledge of metallographic testing of engineering materials.
4. Understand the various heat treatment process of metals.
5. Know the types, advantages and applications of various NDT methods.

Module-1	**RBT Level**	Hrs.
1. Hardness Testing – Vicker's, Brinell, Rockwel	L1, L2, L3	3
2. Tensile Test	L1, L2, L3	3
3. Flexural Test	L1, L2, L3	3
4. Torsional Test	L1, L2, L3	3
5. Impact Test	L1, L2, L3	3
6. Shear Test	L1, L2, L3	3
7. Fatigue Test	L1, L2, L3	3
8. Preparation of specimen for metallograpic examination of different engineering materials. Identification of microstructures of plain carbon steel, tool steel, gray C.I, SG iron, Brass, Bronze & metal matrix composites	L1, L2, L3	3
9. Heat treatment: Annealing, normalizing, hardening and tempering of steel. Hardness studies of heat-treated samples.	L1, L2, L3	3

10. To study the wear characteristics of ferrous, non-ferrous and composite materials for different parameters.	L1, L2, L3	3
11. Visual Testing Technique, Dye penetration testing. To study the defects of Cast and Welded specimens.	L1, L2, L3	3
12. Magnetic Particle Inspection.	L1, L2, L3	3
13. Ultrasonic Inspection.	L1, L2, L3	3

Course outcomes:

CO1	Examine the relations among materials properties.
CO2	Differentiate the formation, properties and significance of the alloys through different experiments.
CO3	Apply the knowledge of metallographic testing in aircraft materials.
CO4	Examine the heat treatment process to improve the properties of aircraft materials.
CO5	Analyze the types, advantages and applications of various NDT methods.

Reference Books:

1	Jindal U. C., Strength of Materials, 2012.
2	Mikell. P. Groover, Fundamentals of modern manufacturing materials, processes and systems, Second Edition, 2015.
3	Beer and Johnston E.R., Mechanics of Material, 3rd Edition, Tata McGraw Hill,NewDelhi,2007.
4	Joseph R. Davis, Tensile Testing, 2nd Edition, 2004.
5	Titterton G F, Aircraft Material and Processes, English Book Store, New Delhi, 5th edition, 1998.
6	Hearn E,J., Mechanics of Material, Pergaman Press, England,1972.
7	G.E. Dieter, Mechanical Metallurgy, SI Metric Edition, McGraw – Hill.

CO-PO Mapping

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

CO3	3	1	3	0	0	0	0	0	1	0	1	1
CO4	3	0	1	0	0	0	0	0	0	0	1	1
CO5	3	0	2	0	0	0	0	0	1	0	0	0

High-3, Medium-2, Low-1

Course Title	**MEASUREMENT AND METROLOGY LAB**	Semester	IV
Course Code	**MVJ19AEL47B**	**CIE**	50
Total No. of Contact Hours	42 L : T : P :: 0 : 0 : 42	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	2	**Exam. Duration**	3 Hrs

Course objectives: This course will enable students to

1. Learn the concepts of mechanical measurements and metrology
2. Use the concept of accuracy, error and calibration
3. Acquire the knowledge of basic metrological instruments

1. Calibration of Pressure Gauge
2. Calibration of Thermocouple
3. Calibration of LVDT
4. Calibration of Load cell
5. Determination of modulus of elasticity of a mild steel specimen using strain gauges.
6. Comparison and measurements using vernier caliper and micrometer
7. Measurement of vibration parameters using vibration setup.
8. Measurements using Optical Projector / Toolmaker Microscope.
9. Measurement of angle using Sine Center / Sine bar / bevel protractor
10. Measurement of alignment using Autocollimator / Roller set
11. Measurement of Screw threads Parameters using Two-wire or Three-wire method.
12. Measurements of Surface roughness, Using Tally Surf/Mechanical Comparator

13. Measurement of gear tooth profile using gear tooth vernier /Gear tooth micrometer
14. Calibration of Micrometer using slip gauges

Course outcomes:

After studying this course, students will be able to:

1. Use different measuring tools related to experiments.
2. Identify, define, and explain accuracy, precision, and some additional terminology.
3. Conduct, Analyze, interpret, and present measurement data from measurements experiments.

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

High-3, Medium-2, Low-1

Course Title	**COMPUTER AIDED AIRCRAFT DRAWING**	Semester	IV
Course Code	**MVJ19AEL48/ASL48**	**CIE**	50
Total No. of Contact Hours	42 L : T : P :: 0 : 0 : 42	**SEE**	50
No. of Contact Hours/week	3	**Total**	100

Credits	2	Exam. Duration	03

Course objective is to:

1. Understand and interpret drawings of machine and aircraft components
2. Prepare assembly drawings either manually or by using standard CAD packages.
3. Familiarize with standard components and their assembly of an aircraft.

PART A	RBT Level	Hrs.
Sections of Solids: Sections of Pyramids, Prisms, Cubes, Tetrahedrons, Cones and Cylinders resting only on their bases (No problems on axis inclinations, spheres and hollow solids). True shape of sections. **Orthographic Views:** Conversion of pictorial views into orthographic projections of simple machine parts with or without section. (Bureau of Indian Standards conventions are to be followed for the drawings) Hidden line conventions. Precedence of lines. Laboratory Sessions/ Experimental learning: CAAD Lab Applications: Helps to understand Engineering Drawing. Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=DMtZxp8eFWk&list=PLIhUrsYr8yHwAbiCATZUbzd_CpF0EHF3v https://www.youtube.com/watch?v=f1Hdtf_iAWk	**L1 L2 L3**	10

PART B	RBT Level	Hrs.
Thread Forms: Thread terminology, sectional views of threads. ISO Metric (Internal & External) BSW (Internal & External) square and Acme. Sellers thread, American Standard thread. **Fasteners:** Hexagonal headed bolt and nut with washer (assembly), square headed bolt and nut with washer (assembly) simple assembly using stud bolts with nut and lock nut. Flanged nut, slotted nut, taper and split pin for locking, counter sunk head screw, grub screw, Allen screw. **Keys & Joints:** Parallel key, Taper key, Feather key, Gibhead key and Woodruff key. **Riveted Joints:** Single and double riveted lap joints, butt joints with single/double cover strap. **Couplings:** Split Muff coupling, protected type flanged coupling, pin (bush) type flexible	**L1 L2 L3**	10

coupling, Oldham's coupling and universal coupling (Hooks' Joint) Laboratory Sessions/ Experimental learning: CAAD Lab Applications: For Manufacturing Aerospace Components. Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=70hESLwUhME https://www.youtube.com/watch?v=Gdvtw0pTAOs		
PART C	**RBT Level**	Hrs.
1.Modeling of propeller and hub assembly 2.Modeling of wing assembly 3.Modeling of fuselage assembly 4.Modeling of Engine Mounts 5.Modeling of main rotor blade assembly of helicopter 6.Modeling of UAV assembly 7.Modeling of Landing Gear Assembly Laboratory Sessions/ Experimental learning: CAAD Lab Applications: To Design an Aircraft Model. Video link / Additional online information (related to module if any): https://www.youtube.com/watch?v=rmlUXhvJHt0 https://www.autodesk.com/autodesk-university/class/Fusion-360-and-SketchBook-Teammates-2016#chapter https://www.autodesk.in/solutions/cad-cam	**L1 L2 L3 L4 L5**	22
Laboratory Sessions		
COMPUTER AIDED AIRCRAFT DRAWING		
Course outcomes:		
CO1	Distinguish drawings of machine and aircraft components	
CO2	Identify assembly drawings either manually or by using standard CAD packages.	
CO3	Practice with standard components and their assembly of an aircraft.	

Reference Books:

1.	Engineering Drawing - N.D. Bhatt & V.M. Panchal, 48th edition, 2005- Charotar Publishing House, Gujarat.
2.	"Computer Aided Engineering Drawing" by Dr. M H Annaiah, Dr C N Chandrappa and Dr B Sudheer Premkumar Fifth edition, New Age International Publishers.
3	Computer Aided Engineering Drawing - S. Trymbaka Murthy, - I.K. International Publishing House Pvt. Ltd., New Delhi, 3rd revised edition- 2006
4	Engineering Graphics - K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.
5	Fundamentals of Engineering Drawing with an Introduction to Interactive Computer Graphics for Design and Production- Luzadder Warren J., Duff John M., Eastern Economy Edition, 2005- Prentice-Hall of India Pvt. Ltd., New Delhi.
6	A Primer on Computer Aided Engineering Drawing-2006, Published by VTU, Belgaum.

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

High-3, Medium-2, Low-1