Semester IV (Department of Mechanical 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	BSC	MVJ19MAT41	Complex Variables and Numerical Methods	Mathematics	2	2	0	3	50	50	100	3
2	PCC	MVJ19ME42	Applied Thermodynamics	ME	3	2	0	3	50	50	100	4
3	PCC	MVJ19ME43	Manufacturing Technology	ME	3	0	0	3	50	50	100	3
4	PCC	MVJ19ME44	Kinematics of Machines	ME	2	2	0	3	50	50	100	3
5	PCC	MVJ19ME45	Fluid Mechanics	ME	2	2	0	3	50	50	100	3
6	PCC	MVJ19ME46	Instrumentation and Control	ME	3	0	0	3	50	50	100	3
7	PCC	MVJ19MEL47	Machine shop-Lab	ME	0	1	3	3	50	50	100	2
8	PCC	MVJ19MEL48	Instrumentation and measurement-Lab	ME	0	1	3	3	50	50	100	2
9	HSMC	MVJ19KAN49	Kannada	Humanities	1	0	0	3	50	50	100	1
		MVJ19CPH49	CPH		1	0	0	3	50	50		
10	BSC	MVJ19MATDIP 401	Additional Mathematics-2	Mathematics	1	0	0	3	50	50	100	-
Total					17	10	6	30	500	500	1000	24

Note: BSC: Basic Science, PCC: Professional Core Course , HSMC: Humanity and Social Science
MVJ19MXXDIP401- Mandatory non-credit course

Course Title	COMPLEX VARIABLES AND NUMERICAL METHODS	Semester	IV
Course Code	MVJ19MAT41	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	03	**Exam. Duration**	3 hrs

Course objective is 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 functional.
- 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** L2,L3,L4	12 Hrs.

Complex variables - 1: Functions of complex variables, Analytic function, Cauchy-Riemann Equations in Cartesian and polar coordinates, Consequences of Cauchy-Riemann Equations, Construction of analytic functions (Using Milne-Thomson method).

Transformations: Bilinear Transformation, Conformal transformation, Discussion of the transformations $w = z^2$, $w = e^z$ and $w = z + \frac{a}{z}, (z \neq 0)$.

Applications: Applications to flow problems.

Web Link and Video Lectures:

1. https://www.khanacademy.org/
2. http://www.nptelvideos.in/
3. https://www.classcentral.com/

Module-2	**RBT Level** L2,L3,L4	12 Hrs.

Complex variables-2: Complex integration - Cauchy theorem, Cauchy's Integral Theorem-Problems, 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** L2,L3	12 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/

Module-4	**RBT Level** L2,L3	12 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.

Applications: Hanging Chain problem.

Web Link and Video Lectures:

1. https://www.khanacademy.org/
2. http://www.nptelvideos.in/
3. https://www.classcentral.com/

Module-5	**RBT Level** L2, L3	12 Hrs.

Numerical methods-3: Numerical solution of Partial Differential Equations: Introduction, Finite difference approximations to derivatives, Numerical Solution of Laplace 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 Con-formal 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	APPLIED THERMODYNAMICS	Semester	IV
Course Code	MVJ19ME42	**CIE**	50
Total No. of Contact Hours	60 L: T : P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	04	**Exam. Duration**	3 Hrs

Course objective is to:

- Students should be able to understand different PV & TS diagram for Air standard cycles, (Carnot Cycle, Otto Cycle, Diesel Cycle, Dual Cycle, & MEP for the same).
- Can learn the concepts of combustion and the requirements involved for complete combustion.
- Can learn concepts of IC engines, Calculations of BP, IP, Mechanical efficiency, Heat balance sheet etc.
- Applications of Thermodynamics principles to Gas and vapour power cycles.
- Performance analysis of R.A.C and optimization of compression.

Module-1	**RBT Level** L1, L2,L3	12 Hrs.

Air Standard and Gas power cycles: Carnot cycle, Air standard Otto, Diesel and Dual cycles, efficiency and mean effective pressure derivation. Ideal Brayton cycle, effect of reheat, regeneration and Intercooling-

(Numerical problems on Otto, Diesel, Dual and ideal Brayton cycle only.).

Laboratory Sessions/ Experimental learning:

Applications: Heat engines of all types form a very important and commercially used application based on thermodynamic principles.

Video link / Additional online information :

1. https://youtu.be/LDXLOCTeJQE,
2. https://youtu.be/b5SPb6NHna4,
3. https://youtu.be/PB7n8Y74890
4. https://youtu.be/Op1b1j0ViJg
5. https://youtu.be/_LSq4iPqHPY,
6. https://youtu.be/oh5HgxEz6dk
7. https://youtu.be/OsYA6gPFPrk

Module-2	**RBT Level** L1, L2,L3	10 Hrs.

Combustion Thermodynamics: Theoretical (Stoichiometric) air for combustion of fuels, excess air, mass balance, actual combustion. Exhaust gas analysis. A/F ratio, energy balance for a chemical reaction.

(Numerical problems on combustion of fuels only)

Laboratory Sessions/ Experimental learning:

- Using cut section model amount of charge entering into cylinder can be analyzed.

Applications: Proper mixing of air fuel mixture is learnt for complete combustion process.

Module-3	**RBT Level** L2,L3, L4	14 Hrs.

Internal Combustion Engines: Classification of IC engines, Combustion of SI engine and CI engine, Detonation and factors affecting detonation, Performance analysis of I.C Engines, heat balance, Morse test, Willian's line method, (Numerical problems on Heat balance sheet and Morse test only).

Refrigeration:

Vapour compression refrigeration system, description, Refrigerating effect, capacity, Power required, Units of refrigeration, COP, Refrigerants and their desirable properties, Vapour absorption refrigeration system.

Laboratory Sessions/ Experimental learning:

- Performance parameters, Morse test and heat balance analysis can be found by conducting the experiments in Energy conversion laboratory.

Applications: Work can be extended related to pollution control methods.

Video link / Additional online information:

https://youtu.be/2iYqZ8tIP1I, https://youtu.be/BofCLgFqlSg

https://youtu.be/ICgjx-WX6UM

https://youtu.be/cobFAMZDS0o

https://youtu.be/oclgDmwEfZY

Module-4	**RBT Level** L2,L3 L4	12 Hrs.

Vapour Power Cycle: Rankine Cycle ideal and actual. Mean temperature of heat addition. Reheat Cycle, Ideal Regenerative Cycle, and Regenerative Cycle with feed water heaters. Binary Vapour Cycle. Problems.

Video link / Additional online information:

1. https://youtu.be/4-BI22Wx4Pc,
2. https://youtu.be/vt1_7f5l3hI,
3. https://youtu.be/NtoTpeWAAWc
4. https://youtu.be/N86Wi6npX5Y

Module-5	L2,L3, L4	12 Hrs.

Reciprocating Compressors: Operation of a single stage reciprocating compressors. Work input through p-v diagram and steady state steady flow analysis. Effect of Clearance and Volumetric efficiency. Adiabatic, Isothermal and Mechanical efficiencies. Multi-stage compressor, saving in work, Optimum intermediate pressure, Inter-cooling, Minimum work for compression.

Laboratory Sessions/ Experimental learning:

- Performance analysis of air compressor will be analyzed by conducting the experiment related to air compressor available in Fluid mechanics and machines laboratory.

Video link / Additional online information:

https://youtu.be/zX8PnPCGRLE, https://youtu.be/9fVLoe9Y_L8

Course outcomes:	
CO1	Explain various thermodynamic processes and air standard power cycles with p-v and T-s diagrams; derive expressions of efficiency and mean effective pressure of power cycles; understand the measurement of various parameters to assess the performance of internal combustion engines
CO2	Describe the actual process of combustion involved in I.C. Engines and processes involved in reduction of pollution.
CO3	Describe the performance parameters of I.C. Engines and comparison of the parameters to improve the efficiency of the same.
CO4	Understand and compare the Carnot and Rankine vapour power cycles with T-s diagrams; derive expressions for efficiency and solve related numerical problems.
CO5	Describe the working principle of reciprocating air compressor; derive the expressions for its performance and solve related numerical problems

Reference Books:	
1.	**Onkar Singh**, "**Engineering Thermodynamics**", New Age International Publishers, First edition, 2006.
2.	**Yunus, A. Cengel and Michael A.Boles, *"Thermodynamics, An Engineering approach",*** Tata McGraw Hill pub. Co., 2011.
3.	**V. Kadambi, T.R. Seetharam, K.B. Subramanya Kumar**, "**Applications of Thermodynamics**", Wiley publication, First Edition, 2019.
4.	**A. Domkundwar, C.P. Kothandaraman, S. Domkundwar**, "***A Course in Thermal Engineering"*** Danpat Rai and Co (P) Limited, 2013.

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

High-3, Medium-2, Low-1

ONLINE RESOURCES

Topic/Title	Link
Applied Thermodynamics	http://nptel.ac.in/courses/112106133/
Thermodynamics	https://ocw.mit.edu/courses/physics/8-333-statistical-mechanics-i-statistical-mechanics-of-particles-fall-2013/video-lectures/lecture-1-thermodynamics-part-1/
Applied thermodynamics	http://nptel.vtu.ac.in/econtent/web/ME/17ME43/index.php
Applied thermodynamics	http://nptel.vtu.ac.in/econtent/courses/ME/06ME43/index.php

Course Title	MANUFACTURING TECHNOLOGY	Semester	IV
Course Code	MVJ19ME43	**CIE**	50
Total No. of Contact Hours	60 L: T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- This course will highlight topics related to sheet metal forming and high energy forming process equipment's, with applications in various disciplines in engineering and science.
- The course will deal with welding technology, also thermal and metallurgical consideration of welded material.
- The course will deal with milling shaping and drilling of materials using single and multipoint cutting tool.
- Deals with the Gear cutting methodology and finishing operation.

Module-1	**RBT Level** L1, L2	12 Hrs.

Introduction to Sheet metal forming: Mechanical, Hydraulic and pneumatic press machines, applications and limitations of Presses, Shearing, blanking, piercing, punching, nibbling, lancing, notching and non – shearing, bending, stretching, spinning, embossing, coining, drawing, operation & applications of stretch forming & deep drawing, defects in sheet metal formed components, simple numericals to estimate the force requirement in punching.

High Energy Rate Forming: operation & applications of explosive forming, Electro hydraulic forming & Electromagnetic forming.

Laboratory Sessions/ Experimental learning:

- Joining Different metals using different welding process and studying about identification about difference defect by available methods.

Applications: Automobile industry, Aerospace Industry, all type of sheet metal industry.

Video link / Additional online information: https://www.youtube.com/watch?v=JgNaSll8Obo

Module-2	**RBT Level** L1,L2,L3	12 Hrs.

Introduction to Welding: Oxy-acetylene welding, types of flames, welding torches, welding techniques. Resistance welding-spot, seam, projection and butt welding. Laser beam welding, Electron beam welding. Friction welding, Friction stir welding and Ultra sonic welding.

Thermal and metallurgical consideration: Temperature distribution, heating and cooling curves, HAZ and parent metal, micro and macro structures, solidification of weld and properties.

Welding defects and Inspection: Visual, Magnetic Particle, Fluoroscent particle, ultrasonic, Radiography, Eddy current, holography methods of inspection.

Laboratory Sessions/ Experimental learning:

- Studying about single point cutting tool and its geometry.

Applications: Heavy fabrication industry.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=g7MkIBdl06c&list=PLwdnzlV3ogoUQnGO8eFFygVBTjF0xyYMq
2. https://www.youtube.com/watch?v=mmKy5PbndQI&list=PLyqSpQzTE6M-KwjFQByBvRx464XpCgOEC

Module-3	**RBT Level** L1,L2,L3	12 Hrs.

Theory of Metal Cutting: Single point cutting tool nomenclature, Merchants circle diagram and simple problems. Tool wear, tool life, Taylor's tool life equation, effects of cutting parameters on tool life, cutting tool materials, Properties of cutting fluids.

Shaping, Slotting and Planing Machines Tools: Driving mechanisms of Shaper, Slotter and Planer. Operations done on Shaper, Planer & Slotter. Difference between shaping and planning operations.

Laboratory Sessions/ Experimental learning:

- Merchant circle diagram can be drawing extracting Cutting force and Thrust force using Tool dynamo meter.

Applications: All manufacturing industry.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=-R-fySRLa9Q
2. https://www.youtube.com/watch?v=i06a7OnIkDk

Module-4	**RBT Level** L1,L2,L4	12 Hrs.

Drilling Machines: Constructional features (Radial & Bench drilling Machines), operations, types of drill & drill bit nomenclature. Calculation of machining time.

Milling Machines: constructional features (Column and knee and vertical. Milling Machine), milling cutters nomenclature, milling operations, calculation of machining time.

Indexing: Simple, compound, differential and angular indexing calculations. Simple numerical on indexing.

Grinding: Abrasives and bonding, mounting, truing and dressing of grinding wheels.

Introduction to lapping, honing and broaching.

Laboratory Sessions/ Experimental learning:

- Indexing in gear cutting operation can be performed using the milling machine with varying number of gear teeth in gear.

Applications: All manufacturing industry

Video link / Additional online information:

1. https://www.youtube.com/watch?v=Rf90Jbbcr3M
2. https://www.youtube.com/watch?v=IR2KhMTl5RM

Module-5	**RBT Level** L1,L2	12 Hrs.

Gear Cutting Technology:

Gear Milling: Gear milling machine, worm gear milling, bevel gear milling, milling cutters.

Gear Hobbing: Principle of Hobbing process, advantages and limitations of Hobbing process. Hobbing techniques, Hobbing cycles, Hobbing of Worm Wheels.

Gear Shaping: Principle of Gear shaping process, advantages and limitations, Helical Gear shaping: Relationship between cutter teeth and helical guide.

Gear Finishing Process: Gear Shaving, Gear Lapping and Gear Grinding, Gear burnishing, Gear Honning.

Laboratory Sessions/ Experimental learning:

- Gear cutting can be practiced using shaper machine

Applications: Power transmission industry.

Video link / Additional online information: https://www.youtube.com/watch?v=B8w-0Oi0Yf4

Course outcomes:	
CO1	Students will able to understand Sheet metal forming
CO2	Students able to understand the welding process.
CO3	Able to understand removal of metal using a cutting tool.
CO4	Students will study about milling drilling and grinding machines.
CO5	Analyse and understand Gear cutting technology.

Reference Books:	
1.	**S K Hajara Choudhury *"Work shop technology"*** Volume I and II, Media promoters & publishers

2.	***Production Technology: HMT*** Tata McGraw Hill Publishing Co. Ltd.,New Delhi, 1999.
3.	**William K Dalton, Gregg Bruce R, "*Modern Materials and Manufacturing Processes*"**, Pearson Education, 2007
4	**Rao P N, "*Manufacturing Technology*",** Tata McGraw Hill Publishing Co. Ltd., New Delhi, 1998.

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

High-3, Medium-2, Low-1**.**

Course Title	KINEMATICS OF MACHINES	Semester	IV
Course Code	MVJ19ME44	**CIE**	50
Total No. of Contact Hours	60 L : T : P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	03	**Exam. Duration**	03 hrs

Course objective is to:

- Explain the types of relative motion to differentiate between Machine, Mechanism, and Structure
- Draw velocity and acceleration diagrams of linkages.
- Determine gear parameters and determine train value & fixing torque in gear trains.
- Design Cam profile for the desired follower motion.

Module-1	**RBT Level** L1,L2	12 Hrs.

Introduction: Definition of link, pair, kinematic chain, mechanism, machine, inversion, structure – Types of motion, Grashof's criterion, Inversions of 4 bar chain, single slider crank chain and double slider crank chain – Degrees of freedom – Gruebler's criterion for mobility of mechanisms.

Mechanisms: Drag link and toggle mechanisms – Straight line mechanisms, Condition for exact straight line motion, Peaucellier and Hart mechanisms – Intermittent motion mechanisms, Ratchet and pawl and Geneva wheel – Pantograph, Condition for perfect steering, Steering gear mechanisms, Ackermann– Hooke's joint, Oldham's Coupling.

Laboratory Sessions/ Experimental learning:

- Preparing simple mechanism models such as single slider crank chain and double slider crank chain, Ratchet and pawl and Geneva wheel.

Applications: These mechanisms are used in trains, automobile vehicles and robotics.

Video link / Additional online information: https://nptel.ac.in/courses/112105268/

Module-2	**RBT Level** L3, L4	12 Hrs.

Velocity and Acceleration: Determination of velocity and acceleration of a point/link in simple mechanisms by relative velocity method (graphical) – Coriolis component of acceleration.

Instantaneous centre – Centrodes – Kennedy's theorem – To determine linear velocity and angular velocity of links of simple mechanisms by instantaneous centre method. Klein's Construction for

velocity and acceleration of slider crank mechanism.

Laboratory Sessions/ Experimental learning:

- Analysis of velocity and acceleration of single slider crank chain and four bar chain by complex algebra method.

Applications: These methods are adopted in ships to know the directions of movement.

Video link / Additional online information: https://swayam.gov.in/nd1-noc20-me21/

Module-3	**RBT Level** L2, L3,L4	12 Hrs.

Spur Gear : Classification of toothed wheels – Gear terminology –Law of gearing –Velocity of sliding – Length of path of contact, Arc of contact – Contact ratio – Interference in involute gears, Methods of avoiding interference –Minimum number of teeth to avoid interference on pinion meshing with gear and on pinion meshing with rack. Characteristics of involutes action, Comparison of involute and cycloidal teeth profiles. Numerical problems.

Laboratory Sessions/ Experimental learning:

- Building of spur gears prototype.

Applications: It can be used in different machines and automobile vehicles to vary the running speed.

Video link / Additional online information: https://nptel.ac.in/courses/1121/104/112104121/

Module-4	**RBT Level** L2, L3, L4	12 Hrs.

Gear Trains–Velocity ratio & Train value, Types of gear trains– Simple, Compound, Reverted & Epicyclic gear trains. Algebraic/Tabular method of finding Train value of Epicyclic gear trains. Numerical problems.

Laboratory Sessions/ Experimental learning:

- Building of gears trains prototype.

Applications: It can be used in different machines and automobile vehicles to run at different speeds.

Video link / Additional online information : https://nptel.ac.in/courses/1121/104/112104121/

Module-5	**RBT Level** L3, L4, L5	12 Hrs.

Cams: Types of cams, Types of followers and types of follower motion –Displacement, velocity and acceleration curves for SHM, Uniform velocity, UARM and Cycloidal motion – To draw cam profile for disc cam with reciprocating follower (knife edge, roller and flat faced)– To find maximum velocity and acceleration in each case.

Laboratory Sessions/ Experimental learning:

- Developing the CAM models using Solid Edge.

Applications: CAMS are placed in engine cylinder of vehicles for inlet and outlet valves flow.

Video link / Additional online information: https: //nptel.ac.in/courses/1121/104/112104121/

Course outcomes:

CO1	Define the basic mechanisms for developing a machine.
CO2	Construct velocity and acceleration diagram for mechanism
CO3	Design and synthesize mechanisms for specific type of relative motion
CO4	Estimate kinematic parameters for industrial mechanism of gears.
CO5	Construct the Cams for various followers.

Reference Books:

1.	**S S RATHAN**: "***Text Book of Theory of Machines"***, 4th Edition, McGraw-Hill Education,(IND private limited.
2.	**SADHU SINGH** : "***Theory of Machines"***, 2nd Edition, Pearson Education Publications, 2007
3.	**R S KHURMI, J K GUPTA** : "***A Text Book of Theory of Machines"***, S CHAND publication.
4.	**GHOSH A. AND MALLICK A.K** : ***"Theory of Mechanisms and Machines"***, Affiliated East-West Pvt. Ltd, New Delhi, 1988.

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

High-3, Medium-2, Low-1

Course Title	FLUID MECHANICS	Semester	IV
Course Code	MVJ19ME45	**CIE**	50
Total No. of Contact Hours	60 L: T : P :: 40 : 10 : 10	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- To have a working knowledge of the basic properties of fluids and understand the continuum approximation.
- To calculate the forces exerted by a fluid at rest on submerged surfaces and understand the force of buoyancy.
- To understand the flow characteristic and dynamics of flow field for various Engineering applications.
- To know how velocity changes and energy transfers in fluid flows are related to forces and torques and to understand, why designing for minimum loss of energy in fluid flows is so important.
- To discuss the main properties of laminar and turbulent pipe flow and appreciate their differences and the concept of boundary layer theory.
- Understand the concept of dynamic similarity and how to apply it to experimental modelling.

Module-1	**RBT Level** L1, L2	11 Hrs.

Prerequisites: Basics of fluid properties, manometer, buoyancy.

Basics: Introduction, Properties of fluids-mass density, weight density, specific volume, specific gravity, viscosity, surface tension, capillarity, vapour pressure, compressibility and bulk modulus. Concept of continuum, types of fluids etc, pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, Absolute, gauge, atmospheric and vacuum pressures pressure measurement by simple, differential manometers and mechanical gauges.

Laboratory Sessions/Experimental learning:

- Calculating density of different oils.

Applications: Measurement of pressure drop in different joints, valves and also in calibration of gauges.

Video link / Additional online information:

https://lake.videoken.com/nptel/search/fluid%20mechanics/video/NH6fDKPNjMk?tocitem=2

Module-2	RBT Level L1, L2	12 Hrs.

Prerequisites: Basics of fluid flow, Laplace equation.

Fluid Statics: Total pressure and centre of pressure for horizontal plane, vertical plane surface and inclined plane surface submerged in static fluid. Buoyancy, centre of buoyancy, meta centre and meta centric height, application in shipping, stability of floating bodies.

Fluid Kinematics: Fluid Kinematics: Types of Flow-steady , unsteady, uniform, non-uniform, laminar, turbulent, one, two and three dimensional, compressible, incompressible, rotational, ir-rotational, stream lines, path lines, streak lines, velocity components, convective and local acceleration, velocity potential, stream function, continuity equation in Cartesian co-ordinates. Rotation, vorticity and circulation, Laplace equation in velocity potential and Poisson equation in stream function, flow net, Problems.

Laboratory Sessions/ Experimental learning:

- Estimate total pressure and buoyancy of objects submerged in fluid.

Applications: Measure of fluid flow pattern in pipelines.

Video link / Additional online information:

https://lake.videoken.com/nptel/search/Lec-3%20Fluid%20Statics/video/DpsRNq5mlVQ?tocitem=3

Module-3	RBT Level L1, L3	13 Hrs.

Prerequisites: Basics of fluid flow, Differential Equations.

Fluid Dynamics: Momentum equation, Impacts of jets- force on fixed and moving vane, flat and curved. Numerical. Euler's equation, Integration of Euler's equation to obtain Bernoulli's equation, Bernoulli's theorem.

Introduction to Navier-Stokes equation, application of Bernoulli's theorem such as venturimeter, orifice meter, rectangular and triangular notch, pitot tube.

Laboratory Sessions/ Experimental learning:

- Study and use of venturimeter, orificemeter and pitot tube.

Applications: Flow rate of blood in arteries.

Video link / Additional online information:

https://lake.videoken.com/nptel/search/fluid%20mechanics/video/6k6Iyf_Xu-8?tocitem=10

Module-4	RBT Level L1, L2, L3	13 Hrs.

Prerequisites: Basics of Reynolds number, laminar flow, fluid friction.

Laminar and turbulent flow: Reynolds Number, Entrance flow and Developed flow, Navier-Stokes Equation (no derivation), Laminar flow between parallel plates, Poiseuille equation – velocity profile, Couette flow, Fully developed laminar flow in circular pipes, Hagen - Poiseuille equation, related numerical.

Energy consideration in pipe flow, Loss of Pressure Head due to Fluid Friction, Darcy Weisbach formula, major and minor losses in pipes, Commercial pipe, Colebrook equation, Moody equation/ diagram. Pipes in series, parallel, equivalent pipe, Related Numerical and simple pipe design problems.

Laboratory Sessions/ Experimental learning:

- Determining Reynolds number for various fluid flows, analyse the losses in different pipes due to friction.

Applications: To monitor/control smooth flow of viscous liquid through a tube or pipe.

Video link / Additional online information :

https://lake.videoken.com/nptel/search/Laminar%20flow/video/yNbDyOJa76Y?tocitem=7

Module-5	**RBT Level** L1, L2, L3	11 Hrs.

Prerequisites: Basics of Boundary layer, airfoil, Dimensions and units.

Flow over bodies: Development of boundary layer, Prandtl's boundary layer equations, Blasius solution, laminar layer over a flat plate, boundary layer separation and its control.

Basic concept of Lift and Drag, Types of drag, Co-efficient of drag and lift, streamline body and bluff body, flow around circular bodies and airfoils, Lift and drag on airfoil, Numerical problems.

Dimensional analysis: Need for dimensional analysis, Dimensions and units, Dimensional Homogeneity and dimensionless ratios, methods of dimensional analysis, Rayleigh's method, Buckingham Pi theorem, Similitude and Model studies. Numerical problems.

Laboratory Sessions/ Experimental learning:

- Preparing different aerofoils and estimate the drag and lift co-efficient. Study of Boundary layer and its control.

Applications: Measure and control angle of attack of airfoil, calculation of shear drag, which breaks boundary layer.

Video link / Additional online information :

https://lake.videoken.com/nptel/search/Boundary%20layer/

Course outcomes:	
CO1	Identify and calculate the key fluid properties used in the analysis of fluid behaviour.
CO2	Understand and apply the principles of pressure, buoyancy and floatation.
CO3	Apply the knowledge of fluid statics and kinematics while addressing problems of mechanical engineering.
CO4	Apply the knowledge of fluid dynamics to analyze the flow instruments like venture meter, orifice meter and pitot tube.
CO5	Understand and apply the knowledge of Dimensional analysis, lift and drag in airfoil.

Reference Books:	
1.	**Munson, Young, Okiishi & Huebsch, *"Fundamentals of Fluid Mechanics",*** 6th Edition, John Wiley Publications, 2009.
2.	**Yunus A. Cengel John M.Cimbala, *"Fluid Mechanics (SI Units)",*** 3rd Edition, Tata McGraw Hill, 2014.
3.	**Fox, McDonald,** "***Introduction to Fluid Mechanics",*** 8th Edition, John Wiley Publications, 2011.
4.	**John F. Douglas, Janul and M. Gasiosek and John A. Swaffield,** "***Fluid Mechanics",*** 5th Edition, Pearson Education Asia, 2006.

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

High-3, Medium-2, Low-1

Course Title	INSTRUMENTATION & CONTROL	Semester	IV
Course Code	MVJ19ME46	**CIE**	50
Total No. of Contact Hours	60 L: T : P :: 40 : 0 : 20	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- To provide a basic knowledge about measurement systems and their components
- To learn about various sensors used for measurement of mechanical quantities
- To learn about system stability and control.
- To integrate the measurement systems with the process for process monitoring and Control.

Module-1	**RBT Level** L1	11 Hrs.

Prerequisites: Basics of measurements and measuring systems.

Basic Concepts of Measurement and Metrology: Definition and significance of measurement, Generalized measurement system, Performance characteristics of measuring instruments (Only static characteristics), Inaccuracy of Measurements, Definition and objectives of metrology. Standards, Subdivision of standards, Line and end standard, Imperial standard yard, Wave length standard, International Prototype meter, Transfer from line to end standard. Calibration of end bars, Slip gauges, Wringing phenomena, Numerical problems on building of slip gauges.

Laboratory Sessions/ Experimental learning:

- Building dimensions using slip gauges and angle gauges.

Applications: Measurement and manufacturing of other processes, defect detection, Calibration and quality Control.

Video link / Additional online information :

https://lake.videoken.com/nptel/search/Metrology%20/video/BqAmlOl8uzs?tocitem=4

Module-2	**RBT Level** L1, L2	12 Hrs.

Prerequisites: Basics of limits, types of fits, holes and shafts.

System of Limits, Fits, Tolerances and Gauging: Definition of tolerance, specification in assembly, Principle of inter-changeability and selective assembly. Concept of limits of size and tolerances, Compound tolerances, accumulation of tolerances. Definition of fits, types of fits. Hole basis system and shaft basis system, Geometric dimensioning and tolerance.

Classification of gauges, Basic concept of design of gauges (Taylor's principles), wear allowance on gauges. Types of gauges -plain plug gauge, ring gauge, snap gauge, gauge materials. Gauge Design and numerical problems.

Laboratory Sessions/ Experimental learning:

- Study and use of; plug gauge and ring gauges, calculation of wear allowance.

Applications: Providing Allowances and clearance for various applications of holes and shafts.

Video link / Additional online information:

https://lake.videoken.com/nptel/search/System%20of%20Limits%20and%20Fits

Module-3	**RBT Level** L1, L2	12 Hrs.

Prerequisites: Basics of comparators, pressure gauges, screw thread, and gears.

Comparators: Characteristics and classification of comparators. Mechanical comparators-Johnson Mikrokator, Sigma Comparators, Optical Comparators -principles, Zeiss ultra-optimeter, Electric and Electronic Comparators, LVDT, Pneumatic Comparators, Solex Comparator, Back Pressure gauges.

Metrology of Screw Thread and Gear: Measurement of basic elements of thread, Screw threads: 2-wire and 3-wire methods. Gear tooth terminology, Base-tangent method, Constant chord method, Measurement of pitch, Gear roll tester.

Basic concepts of Coordinate measuring machines-construction and applications.

Laboratory Sessions/ Experimental learning:

- Study and Operation of different comparators and pressure gauge.
- Experimental Verification of base tangent method and constant chord method.
- Study of Coordinate measuring machines, its applications.
- Measurement of screw thread and Gear parameters.

Applications: Compare voltages and currents to measure minute and micro displacements.

Video link / Additional online information :

https://lake.videoken.com/nptel/search/Comparators%20

Module-4	**RBT Level** L1, L2	12 Hrs.

Prerequisites: Basic of sensors, transducers, amplifiers and CRO.

Transducers: Introduction, Transfer efficiency, Loading effect, Primary and Secondary transducers, classification of transducers with examples. Advantages of each type transducers.

Signal Conditioning: Mechanical systems, Electrical intermediate modifying devices, Input circuitry-simple current sensitive circuit, Electronic amplifiers, Filters, Types of filters, telemetry, Cathode ray oscilloscope, Oscillographs.

Laboratory Sessions/ Experimental learning:

- Application of oscillograph and CRO.

Applications: Automation and control of Electronic circuits, wireless communication and broadcasting.

Video link / Additional online information : https://lake.videoken.com/nptel/search/Transducers/

Module-5	**RBT Level** L1, L2, L3	13 Hrs.

Prerequisites: Basic of strain, force, torque and temperature.

Strain Measurement: Methods of strain measurement, Strain gauges, Preparation and mounting of strain gauges, Gauge factor.

Measurement of Force: Introduction, Proving ring.

Measurement of Torque: Introduction, Prony or Brake Dynamometer, Hydraulic dynamometer.

Measurement of Pressure: Introduction, Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani Gauge.

Temperature Measurement: Resistance thermometers, Wheatstone bridge circuit, Thermocouple, Laws of thermocouple, Thermocouple materials. Pyrometers, Optical pyrometers.

Laboratory Sessions/ Experimental learning:

- Study of strain gauge and application. Study of thermistors, resistance thermometers and its operation. Study of pyrometer, thermocouple and its use.

Applications: measurement of strain in load bearing structures along load paths, temperature/pressure gradient in high pressure vessels.

Video link / Additional online information:

https://lake.videoken.com/nptel/search/Strain%20gauge/

Course outcomes:	
CO1	Understand the objectives of metrology, methods of measurements, selection of measuring

	instruments, standards of measurement and calibration of end bars.
CO2	Describe the slip gauges, wringing of slip gauges and building of slip gauges, angle measurement using sine bar, sine center, angle gauges, optical instruments and straightness measurement using Autocollimator.
CO3	Explain tolerance, limits of size, fits, geometric and position tolerances, gauges and their design.
CO4	Understand the principle of Johnson mikrokator, sigma comparator, dial indicator, LVDT, back pressure gauge, solex comparator, Zeiss Ultra comparator, functioning of force, torque, pressure, strain and temperature measuring devices.
CO5	Describe measurement of major diameter, minor diameter, pitch, angle, effective diameter of screw thread, understand laser interferometers and coordinate measuring machines.

Reference Books:	
1.	**E.O. Doebelin,** "***Measurement Systems (Applications and Design)***", 5th ed.- -McGraw Hill.
2.	**Beckwith Marangoni and Lienhard, "*Mechanical Measurements*"** Pearson Education, 6th Ed., 2006.
3.	**Richard S Figliola, Donald E Beasley "*Theory and Design for Mechanical Measurements***", 3rd edition, WILEY India Publishers.
4.	**R.K. Jain, "*Engineering Metrology*",** Khanna Publishers, Delhi, 2009**.**

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

High-3, Medium-2, Low-1

Course Title	MACHINE SHOP LAB	Semester	IV
Course Code	MVJ19MEL47	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 00: 10: 30	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	02	**Exam. Duration**	3 hrs

Course objective is to:

- To guide students to use fitting tools to perform fitting operations.
- To provide an insight to different machine tools, accessories and attachments.
- To train students into fitting and machining operations to enrich their practical skills.
- To inculcate team qualities and expose students to shop floor activities.
- To educate students about ethical, environmental and safety standards.

EXPERIMENTS	
PART-A	
1.	Preparation of at least two fitting joint models by proficient handling and application of hand tools- V -block, marking gauge, files, hack saw drills etc.
PART-B	
2.	Preparation of three models on lathe involving - Plain turning, Taper turning, Step turning, Thread cutting, Facing, Knurling, Drilling, Boring, Internal Thread cutting and Eccentric turning. Exercises should include selection of cutting parameters and cutting time estimation.
PART-C	
3.	Cutting of V Groove/ dovetail / Rectangular groove using a shaper. Cutting of Gear Teeth using Milling Machine. Exercises should include selection of cutting parameters and cutting time estimation.
PART-D	
	Study & Demonstration of power tools like power drill, power hacksaw, portable hand grinding, cordless screw drivers, production air tools, wood cutter, etc., used in Mechanical Engineering Demo on CNC milling and turning operations.
Course outcomes:	
CO1	To read working drawings, understand operational symbols and execute machining

	operations.
CO2	Prepare fitting models according to drawings using hand tools- V-block, marking gauge, files, hack saw, drills etc.
CO3	Understand integral parts of lathe, shaping and milling machines and various accessories and attachments used.
CO4	Perform cylindrical turning operations such as plain turning, taper turning, step turning, thread Cutting, facing, knurling, internal thread cutting, eccentric turning and estimate cutting time.
CO5	Perform machining operations such as plain shaping, inclined shaping, keyway cutting, Indexing and Gear cutting and estimate cutting time.

Reference Books:	
1.	**Serope Kalpakjian, Steuen. R, Sechmid, "*Manufacturing Technology*"** Pearson Education Asia, 5th Ed. 2006.
Scheme of Examination:	
1	One question is to be set from either Part-A or Part-C: 20 marks.
2	One question is to be set from either Part-B: 20 Marks
3	Viva – Voce: 10 marks

Course Title	INSTRUMENTATION AND MEASUREMENT LAB	Semester	IV
Course Code	MVJ19MEL48	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 00: 10: 30	**SEE**	50
No. of Contact Hours/week	3	**Total**	100
Credits	02	**Exam. Duration**	3 hrs

Course objective is to:

- To illustrate the theoretical concepts taught in Mechanical Measurements & Metrology through experiments.
- To illustrate the use of various measuring tools & measuring techniques.
- To understand calibration techniques of various measuring devices.

EXPERIMENTS

PART-A

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.

PART-B

6.	Measurements using Optical Projector / Toolmakers' Microscope.
7.	Measurement of angle using Sine Centre / Sine bar / bevel protractor
8.	Measurement of alignment using Autocollimator / Roller set
9.	Measurement of cutting tool forces using: Lathe tool Dynamometer Drill tool Dynamometer.
10.	Measurements of Screw thread parameters using two wire or three-wire methods.
11.	Measurements of surface roughness using Tally Surf/Mechanical Comparator
12.	Measurement of gear tooth profile using gear tooth Vernier/Gear tooth micrometer
13	Calibration of Micrometer using slip gauges
14.	Measurement using Optical Flats

Course outcomes:

CO1	Understand Calibration of pressure gauge, thermocouple, LVDT, load cell, micrometer.
CO2	Apply concepts of Measurement of angle using Sine Centre/ Sine Bar/ Bevel Protractor, alignment using Autocollimator/ Roller set.
CO3	Demonstrate measurements using Optical Projector/Tool maker microscope, Optical flats.
CO4	Analyse tool forces using Lathe/Drill tool dynamometer.
CO5	Analyse Screw thread parameters using 2-Wire or 3-Wire method, gear tooth profile using gear tooth Vernier/Gear tooth micrometre

Reference Books:	
1.	**Beckwith Marangoni and Lienhard "*Mechanical Measurements*"** Pearson Education 6th Ed., 2006.
Scheme of Examination:	
1	One question is to be set from Part-A: 20 marks.
2	One question is to be set from either Part-B: 20 Marks
3	Viva – Voce: 10 marks