Scheme for VI Semester B.E.(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	PCC	MVJ20ME61	Heat and Mass Transfer	ME	3	2	0	3	50	50	100	4
2	PCC	MVJ20ME62	Design of Machine Elements-II	ME	3	2	0	3	50	50	100	4
3	PE	MVJ20ME63X	Professional Elective -2	ME	3	0	0	3	50	50	100	3
4	PE	MVJ20ME64X	Professional Elective -3	ME	3	0	0	3	50	50	100	3
5	OE	MVJ20ME65X	Open Elective – 1	ME	3	0	0	3	50	50	100	3
6	PCC	MVJ20MEL66	CAMA-Lab	ME	0	1	3	3	50	50	100	2
7	PCC	MVJ20MEL67	Heat Transfer Lab	ME	0	1	3	3	50	50	100	2
8	Proj	MVJ20MEP68	Mini-Project	ME				3	50	50	100	2
				Total	15	6	6	24	400	400	800	23
Note: PCC: Professional Core Course , PE: Professional Elective, OE: Open Elective, Proj: Project Work												

Professional Elective -2:

1. MVJ20ME631: Refrigeration and Air-Conditioning,
2. MVJ20ME632: Plastic Processing,
3. MVJ20ME633: Smart Materials and Structures,
4. MVJ20ME634: Finite Element Method

Professional Elective -3:

1. MVJ20ME641:Design of Experiments
2. MVJ20ME642: Computer Integrated Manufacturing,
3. MVJ20ME643: Material Characterisation Techniques,
4. MVJ20ME644: Theory of Elasticity

Open Elective – 1:

1. MVJ20ME651: Automotive Electronics
2. MVJ20ME652: Operation Management
3. MVJ20ME653: Engineering Economics

Note: 1. Audit Course of Machine Learning to be taught in VI Semester.

Course Title	HEAT & MASS TRANSFER	Semester	VI
Course Code	MVJ20ME61	**CIE**	50
Total No. of Contact Hours	50 L : T : P :: 3 : 2 : 0	**SEE**	50
No. of Contact Hours/week	05	**Total**	100
Credits	04	**Exam. Duration**	03 Hrs

Course objective is to:

- Build a strong foundation in heat transfer basics of conduction, convection and radiation modes, two dimensional steady and unsteady heat transfer.
- Work on governing equations and solution procedures for the three modes along with solution of practical problems using empirical correlations.
- Analysis and design of the heat exchangers.
- Boiling and condensation heat transfer.

Module-1	**RBT Level** L1, L2, L4	10 Hrs.

Introduction to three modes of heat transfer, derivation of heat balance equation- Steady one dimensional solution for conduction heat transfer in cartesian, cylindrical and spherical geometry, concept of conduction and film resistances, critical insulation thickness.

Lab sessions: Thermal conductivity experiment in HMT lab.

Write a code/program to estimate the intermediate temperatures in composite wall.

Applications: Insulation of industrial pipelines.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785&index=1

Module-2	**RBT Level** L1, L2, L4	10Hrs.

Lumped system approximation and Biot number, heat transfer through pin fins- Two dimensional conduction solutions for both steady and unsteady heat transfer-approximate solution to unsteady conduction heat transfer by the use of Heissler charts.

Lab sessions: Determination of Effectiveness on a Metallic fin.

Experiment on Transient Conduction Heat Transfer.

Applications: CPU cooling, Transformer cooling and engine cooling in automobiles.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=QcTr0-QrSMY&list=PL5F4F46C1983C6785&index=2

Module-3	RBT Level L1, L2, L4	10Hrs.

Heat convection, basic equations, boundary layers- Forced convection, external and internal flows- Natural convective heat transfer- Dimensionless parameters for forced and free convection heat transfer-Correlations for forced and free convection- Approximate solutions to laminar boundary layer equations (momentum and energy) for both internal and external flow- Estimating heat transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection.

Lab sessions: Determination of Heat Transfer Coefficient in free Convection

Determination of Heat Transfer Coefficient in a Forced Convection

Applications: Heat exchangers, Gas turbine and steam turbine cooling, Refrigeration and air conditioning.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=ACjR7MIFaFw&list=PL5F4F46C1983C6785&index=3

Module-4	RBT Level L2, L3, L4	10 Hrs.

Interaction of radiation with materials, definitions of radiative properties, Stefan Boltzmann's law, black and gray body radiation, Calculation of radiation heat transfer between surfaces using radiative properties, view factors and the radiosity method

Lab sessions: Determination of Emissivity of a Surface.

Determination of Stefan Boltzmann Constant

Applications: Solar power applications, electrical bulbs, microwave oven.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=hjrHtAnW4Ac

Module-5	RBT Level L1, L2, L4	10 Hrs.

Types of heat exchangers, Analysis and design of heat exchangers using both LMTD and & NTU methods, Boiling and Condensation heat transfer, Pool boiling curve, Introduction mass transfer, Similarity between heat and mass transfer.

Lab sessions:

1. Determination of LMDT and Effectiveness in a Parallel Flow and Counter Flow Heat Exchangers.
2. Experiments on Boiling of Liquid and Condensation of Vapour

Applications: Boilers, condensers, radiators, nuclear reactor cooling.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=V8Fa-b6Yx0k

Experiential learning exercise:
1. Take a glass of water. Boil it in a bowl to its saturation temperature. Find the amount of heat transfer both convection and radiation mode from source to water 2. What is the amount of heat loss through radiation in above process? 3. When hot water is poured from a glass to bowl to reduce heat, mention the heat transfer process and find practically the amount of heat transfer 4. Identify a composite wall in the institute and find the heat transfer rate from atmosphere when the sunlight is peak. 5. Heat released from your mobile phones or laptops when used continuously for long time.

Course outcomes:	
CO1	After completing the course, the students will be able to formulate and analyse a heat transfer problem involving any of the three modes of heat transfer.
CO2	The students will be able to estimate heat transfer rates in laminar and turbulent flow situations using appropriate correlations for free and forced convection.
CO3	The students will be able to calculate radiation heat transfer between surfaces using radiative properties.
CO4	The students will be able to design thermal device such as heat exchangers.
CO5	The students will be able to understand better the boiling and condensation phenomenon and study pool boiling curves.

Text Books:	
1	Nag, P.K., "*Heat Transfer*", Tata McGraw Hill, New Delhi, 2002
2	Yunus A. Cengel, "*Heat Transfer A Practical Approach*", Tata McGraw Hill, 2010
3	Holman, J.P., "*Heat and Mass Transfer*", Tata McGraw Hill, 2000
Reference Books:	
1	Ozisik, M.N., "*Heat Transfer*", McGraw Hill Book Co., 1994.
2	Kothandaraman, C.P., "*Fundamentals of Heat and Mass Transfer*", New Age International, New Delhi, 1998.

CIE Assessment:
CIE is based on quizzes, tests, assignments/seminars and any other form of evaluation. Generally, there will be: Three Internal Assessment (IA) tests during the semester (30 marks each), the final IA marks to be awarded will be the average of three tests - Quizzes/mini tests (4 marks) - Mini Project / Case Studies (8 Marks) - Activities/Experimentations related to courses (8 Marks)

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

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

High-3, Medium-2, Low-1

Course Title	DESIGN OF MACHINE ELEMENTS-II	Semester	VI
Course Code	MVJ20ME62	CIE	50
Total No. of Contact Hours	50 L: T: P: 3: 2: 0	SEE	50
No. of Contact Hours/week	05	Total	100
Credits	04	Exam. Duration	3 Hrs

Course objective is:

- To understand various elements involved in a mechanical system.
- To analyse various forces acting on the elements of a mechanical system and design them using appropriate techniques, codes, and standards.
- To select transmission elements like gears, belts, pulleys, bearings from the manufacturer's catalogue.
- To design a mechanical system integrating machine elements.
- To produce assembly and working drawings of various mechanical systems involving machine elements like belts, pulleys, gears, springs, bearings, clutches and brakes.

Module-1	RBT Level L1, L2	10 Hrs.

Springs: Types of springs, spring materials, stresses in helical coil springs of circular and non-circular cross sections. Tension and compression springs, concentric springs; springs under fluctuating loads. Leaf Springs: Stresses in leaf springs, equalized stresses, and nipping of leaf springs. Introduction to torsion and Belleville springs.

Belts: Materials for construction of flat and V belts, power rating of belts, concept of slip and creep, initial tension, effect of centrifugal tension, maximum power condition. Selection of flat and V belts-length & cross section from manufacturers' catalogues. Construction and application of timing belts.

Wire ropes: Construction of wire ropes, stresses in wire ropes, and selection of wire ropes.

Laboratory Sessions/Experimental learning:

- Design project should enable the students to design a mechanical spring system, a belt drive system and a wire rope testing under loads.

Applications:

Springs are used to absorb the shocks or Vibration as in-car springs, railway buffers, etc. To measure the forces as in a spring balance. To apply forces in brakes and clutches to stop the vehicles.

Belt drives are used in cars to deliver power to various components such as alternator, air conditioning system etc. Timing Belts are used in industrial automation machines. Used in generator to transfer from one shaft to another.

Wire ropes are used dynamically for lifting and hoisting in cranes and elevators, and for transmission of mechanical power. Wire rope is also used to transmit force in mechanisms, such as a Bowden cable or the control surfaces of an airplane connected to levers and pedals in the cockpit.

Video link/Additional online information: MOOC and Open courseware:

https://www.youtube.com/watch?v=kAOjuP6X87w,https://www.youtube.com/watch?v=jAawhg6JtyY

https://www.youtube.com/watch?v=MQ5Kcwc83bs,https://www.youtube.com/watch?v=0mb_XMGja_c

https://www.youtube.com/watch?v=knZbWUmitPw,https://www.youtube.com/watch?v=G_D0ceaKQFM

Module-2	RBT Level L1, L2	10 Hrs.

Gear drives: Classification of gears, materials for gears, standard systems of gear tooth, lubrication of gears, and gear tooth failure modes.

Spur Gears*:* Definitions, stresses in gear tooth: Lewis equation and form factor, design for strength, dynamic load and wear.

Helical Gears: Definitions, transverse and normal module, formative number of teeth, design based on strength, dynamic load and wear.

Laboratory Sessions/Experimental learning:

- Design project should enable the students **to design a spur gear**, **helical gear**.

Applications:

Gears are used in place of belt drives and other forms of drives when exact speeds and power transmission must be accurately maintained. Gears can be used between two or more shafts where the centre lines are parallel or at any angle relative to each other, and they may or may not be in the same plane.

Spur gears can be used to increase or decrease the torque, or power, of a given object. Spur gears are used to this effect in washing machines, blenders, clothes dryers, construction equipment, fuel pumps and mills.

Some of the industries where the *helical gears* are commonly used are: Printing, earth-moving and fertilizer industries. Port and power industries, steel and rolling mills. Textile industries, food industries, plastic industries, elevators, conveyors, compressors, blowers, cutters and oil industries.

Video link/Additional online information: MOOC and Open courseware:

https://www.youtube.com/watch?v=AS0zQhMfJUw&list=PLSGws_74K01_e499POG3gczxcnlJEHMWE

https://www.youtube.com/watch?v=i788-2pq1HA,https://www.youtube.com/watch?v=9XYeur-iVAs

https://www.youtube.com/watch?v=oiBU7yxkpzc,https://www.youtube.com/watch?v=0rnTh6c19HM

Module-3	RBT Level L2, L3	10 Hrs.

Bevel Gears: Definitions, formative number of teeth, design based on strength, dynamic load and wear.

Worm Gears: Definitions, types of worm and worm gears, and materials for worm and worm wheel. Design based on strength, dynamic, wear loads and efficiency of worm gear drives.

Laboratory Sessions/Experimental learning:

- Design project should enable the students **to design a bevel gear**, **worm gear**.

Applications:

Bevel gears are used in differential drives, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile. Bevel gears are used as the main mechanism for a hand drill. Applications of Worm Gear Drives: Gate control mechanisms, Hoisting machines, Automobile steering mechanisms, Lifts, Conveyors, Presses.

Video link/Additional online information: MOOC and Open courseware:

https://www.youtube.com/watch?v=a5A4LeqPtyg

https://www.youtube.com/watch?v=L7i_QDehseg

https://www.youtube.com/watch?v=gj2szHk0OCU

https://www.youtube.com/watch?v=K5_ivdkRXp0

Module-4	RBT Level L1, L2	10 Hrs.

Design of Clutches: Necessity of a clutch in an automobile, types of clutch, friction materials and its properties. Design of single plate, multi-plate and cone clutches based on uniform pressure and uniform wear theories.

Design of Brakes: Different types of brakes, Concept of self-energizing and self-locking of brakes. Practical examples, Design of band brakes, block brakes and internal expanding brakes.

Laboratory Sessions/Experimental learning:

- Design project should enable the students **to design a clutch**, **brake.**

Applications:

A *clutch* is a mechanical device which engages and disengages power transmission especially from driving shaft to driven shaft. In the simplest application, clutches connect and disconnect two rotating shafts (drive shafts or line shafts).

A *brake* is a mechanical device that inhibits motion by absorbing energy from a moving system. It is used for slowing or stopping a moving vehicle, wheel, axle, or to prevent its motion, most often accomplished

by means of friction.

Video link/Additional online information: MOOC and Open courseware:

https://www.youtube.com/watch?v=gOuLq2haqLY,https://www.youtube.com/watch?v=wCu9W9xNwtI

https://www.youtube.com/watch?v=pqF-aBtTBnY,https://www.youtube.com/watch?v=bMg_j5_AGMg
https://www.youtube.com/watch?v=g5n8OqS1Fow,https://www.youtube.com/watch?v=wCu9W9xNwtI
https://www.youtube.com/watch?v=SOgoejxzF8c,https://www.youtube.com/watch?v=8Jr44ybyS7U
https://www.youtube.com/watch?v=devo3kdSPQY,https://www.youtube.com/watch?v=rOT4O-lwzu8
https://www.youtube.com/watch?v=98DXe3uKwfc,https://www.youtube.com/watch?v=6c4deRAhqcA

Module-5	RBT Level L2, L3	10 Hrs.

Lubrication and Bearings: Lubricants and their properties, bearing materials and properties; mechanisms of lubrication, hydrodynamic lubrication, pressure development in oil film, bearing modulus, coefficient of friction, minimum oil film thickness, heat generated and heat dissipated. Numerical examples on hydrodynamic journal and thrust bearing design.

Antifriction bearings*:* Types of rolling contact bearings and their applications, static and dynamic load carrying capacities, equivalent bearing load, load life relationship; selection of deep grove ball bearings from the manufacturers' catalogue; selection of bearings subjected to cyclic loads and speeds; probability of survival.

Laboratory Sessions/Experimental learning:

- Design project should enable the students to design a lubrication system, antifriction bearing system.

Applications:

Lubricants are primarily used to reduce friction stress between surfaces. They have the following uses: As antiwear, antioxidants, and antifoaming agents. As demulsifying and emulsifying agents. Typical applications include: crane hooks, pulverisers, cone crushers and other heavy-load, medium-speed applications. Tapered roller bearings use tapered rollers between tapered inner and outer ring raceways. These rollers are angled, so their surfaces converge at the bearing's axis.

Applications of *Rolling Contact Bearing*: Industrial and automotive gear boxes and at different automobile, Electric motors, Machine tool spindle, small size centrifugal pumps, Automobile front and rear axles.

Video link/Additional online information: MOOC and Open courseware:

https://www.youtube.com/watch?v=grfLkzjyc-o,https://www.youtube.com/watch?v=TsXQsw8EVgA
https://www.youtube.com/watch?v=gxFRlkZMcJY,https://www.youtube.com/watch?v=VwgBSQ5tF3Y
https://www.youtube.com/watch?v=wpretUMnW9g,https://www.youtube.com/watch?v=tP8nzvnqrPY

Guidelines for Laboratory Sessions/Experimental learning:

A group of students (maximum number in a group should be 4) should submit assembly drawing and part drawings, completely dimensioned, indicating the necessary manufacturing tolerances, surface finish symbols and geometric tolerances wherever necessary. Design project must be completed using appropriate solid modelling software. Computer generated drawings must be submitted. Design calculations must be hand written and should be included in the report.

Course outcomes:	
CO1	Apply design principles for the design of mechanical systems involving springs, belts, pulleys, and wire ropes.
CO2	Design different types of gears and simple gear boxes for relevant applications.
CO3	Understand the design principles of brakes and clutches.
CO4	Apply design concepts of hydrodynamic bearings for different applications and select Anti-friction bearings for different applications using the manufacturers, catalogue.
CO5	Apply engineering design tools to product design. Become good design engineers through learning the art of working in a team.

Text Books:	
1.	Machine Design- an integrated approach Robert L. Norton Pearson Education 2nd edition
2.	Shigley's Mechanical Engineering Design Richard G. Budynas,and J. Keith Nisbett McGraw-Hill Education 10th Edition, 2015
Reference Books:	
1.	Design of Machine Elements V. B. Bhandari Tata Mcgraw Hill 4th Ed 2016.
2.	Design Data Hand Book, K.Lingaiah, McGraw Hill, 2nd edition, 2003.

CIE Assessment:

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

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

SEE Assessment:

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

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

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

CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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	REFRIGERATION AND AIR-CONDITIONING	Semester	VI
Course Code	MVJ20ME631	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- Study the basic definition, ASHRAE Nomenclature for refrigerating systems
- Understand the working principles and applications of different types of refrigeration systems
- Study the working of air conditioning systems and their applications
- Identify the performance parameters and their relations of an air conditioning system

Module-1	RBT Level L1, L2	08 Hrs.

Introduction to Refrigeration –Basic Definitions, ASHRAE Nomenclature, Air Refrigeration Cycles-reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems-merits and demerits and applications: Aircraft refrigeration cycles, Joule Thompson coefficient and Inversion Temperature, Linde, Claude and Stirling cycles for liquefaction of air. Industrial Refrigeration-Chemical and process industries, Dairy plants, Petroleum refineries, Food processing and food chain, Miscellaneous.

Laboratory Sessions/ Experimental learning:

- Recognize important standards of Refrigeration and Air conditioning systems available in Heat transfer lab.

Applications: International and Indian Standards and nomenclatures are required to be understood.

Video link / Additional online information:

https://youtu.be/4mWsRUr0A7A

Module-2	RBT Level L2,L3	08 Hrs.

Vapour Compression Refrigeration System(VCRS): Comparison of Vapour Compression Cycle and Gas cycle, Vapour Compression Refrigeration system Working and analysis, Limitations, Superheat horn and throttling loss for various refrigerants, efficiency, Modifications to standard cycle– liquid-suction heat exchangers, Grindlay cycle and Lorenz cycle, Optimum suction condition for optimum COP – Ewing's construction and Gosney's method. Actual cycles with pressure drops, Complete Vapour Compression Refrigeration System, Multi-Pressure, Multi-

evaporator systems or Compound Vapour Compression Refrigeration Systems – Methods like Flash Gas removal, Flash inter cooling and water Inter cooling.

Laboratory Sessions/ Experimental learning:

- An experiment to be conducted on VCR experimental setup available in Heat transfer lab to illustrate the working of a typical VCR system.

Applications: The practical difficulties in application of working principles and applications of VCR refrigeration system.

Video link / Additional online information:

https://youtu.be/XO2PBDMEHfs,

https://youtu.be/WodVKkkWz90

Module-3	RBT Level L2,L3	08 Hrs.

Vapour Absorption Refrigeration Systems: Absorbent – Refrigerant combinations, Water-Ammonia Systems, Practical problems, Lithium- Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly. Practical problems – crystallization and air leakage, Commercial systems. Other types of Refrigeration systems: Brief Discussion on (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration, pulse tube refrigeration, thermoacoustic refrigeration systems.

Laboratory Sessions/ Experimental learning:

- An experiment to be conducted on VAR experimental setup available in Heat transfer lab to illustrate the working of a typical VAR system.

Applications: The practical difficulties in application of working principles and applications of VAR refrigeration system.

Video link / Additional online information:

https://youtu.be/4w3Obp8ILpA

Module-4	RBT Level L2,L3,L4	08 Hrs.

Refrigerants: Primary and secondary refrigerants, Designation of Refrigerants, Desirable properties of refrigerants including solubility in water and lubricating oil, material compatibility, toxicity, flammability, leak detection, cost, environment and performance issues Thermodynamic properties of refrigerants, Synthetic and natural refrigerants, Comparison between different refrigerants vis a vis applications, Special issues and practical implications Refrigerant mixtures – zeotropic and azeotropic mixtures. Refrigeration systems Equipment: Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

Laboratory Sessions/ Experimental learning:

- Find a suitable refrigerant for requirements of refrigeration system.

Applications: Identify suitable refrigerant for various refrigerating systems.

Video link / Additional online information:

https://youtu.be/6_ePn_LkIQM

Module-5	RBT Level L2,L3,L4	08 Hrs.

Air-Conditioning: Introduction to Air-Conditioning, Basic Definition, Classification, power rating, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Psychrometry Different Air-Conditioning Systems-Central – Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air- Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning Systems. Transport air conditioning Systems: Air conditioning systems for automobiles (cars, buses etc.), Air conditioning systems for trains, Air conditioning systems for ships.

Laboratory Sessions/ Experimental learning:

- Design an Air-condition system for requirements provided.

Applications: Compute and Interpret cooling and heating loads in an air-conditioning system.

Video link / Additional online information:

https://youtu.be/nvUhiXD63Eg,

https://nptel.ac.in/courses/112/105/112105128/

Course outcomes:

CO1	Illustrate the principles, nomenclature and applications of refrigeration systems.
CO2	Explain vapor compression refrigeration system and identify methods for performance improvement.
CO3	Study the working principles of air, vapour absorption, thermoelectric and steam-jet and thermo- acoustic refrigeration systems.
CO4	Identify suitable refrigerant for various refrigerating systems
CO5	Compute and Interpret cooling and heating loads in an air-conditioning system.

Text Books:

1.	Stoecker W.F., and Jones J.W., "*Refrigeration and Air-conditioning*", Mc Graw - Hill, New Delhi 2nd edition, 1982
2.	Roy J. Dossat, "*Principles of Refrigeration*", Wiley Limited

Reference Books:

1.	Mc Quistion, *"Heating, Ventilation and Air Conditioning"*, Wiley Students edition,5th edition 2000.

2.	Arora C.P., "*Refrigeration and Air-conditioning*", Tata Mc Graw –Hill, New Delhi, 2nd Edition, 2001.

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CO3	3	3	2	2	3	2	-	-	2	1	2	1
CO4	3	3	2	2	3	1	1	-	2	2	2	2
CO5	3	3	3	3	2	2	2	-	3	2	3	3

High-3, Medium-2, Low-1

Course Title	PLASTIC PROCESSING	Semester	VI
Course Code	MVJ20ME632	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- Introduce various processes involved in manufacturing of plastic products.
- Expose students to the basics of moulding and forming techniques in plastic manufacturing.
- Evolve the methods for fabrication of plastics.

Module-1	**RBT Level** L1, L2, L3	08 Hrs.

Plastic Processing: Basic principle of processing, shape and size, processing parameters, their effect and behavior, Rheology ideal fluids, and real polymers, Effects of melt behavior on processing and product performance.

Injection Moulding: Principles, process variables, moulding cycle, machinery used, parts and function, specification, construction and maintenance of injection moulding machine, start up and shut down procedure, cylinder, nozzles, interaction of moulding variables, press capacity, projected area, shot weight, concepts and their relationship to processing, trouble shooting in injection moulding, microprocessors-controlled injection moulding machines.

Laboratory Sessions/ Experimental learning:

1. Model making of Injection Moulding.
2. Identifying different grades of plastics used for different applications.

Applications: Plastic products used in day-to-day life.

Video link / Additional online information:

1. https://www.youtube.com/watch?reload=9&v=qn16JtE_vLc
2. https://nptel.ac.in/noc/courses/noc21/SEM1/noc21-me17/
3. https://nptel.ac.in/courses/112/107/112107221/
4. https://www.youtube.com/watch?v=iUH_EdNNtDU

Module-2	**RBT Level** L1, L2, L3	08 Hrs.

Extrusion: Basic principles of extruders, and extrusion process, different types of extrudes i.e. barrel, screw, drive mechanics, head, constructional features of dies, sizing and haul-off

equipment for extruders of mono filaments and tubes, blown film lines, wire and cable covering system, pipe profile extrusion, co-extrusion, process variables in extrusion like heating, temperature control, dies well, and melt fracture, spacing and orientation, treating, printing and sealing, quality of extruder products, fault, causes and remedy.

Laboratory Sessions/ Experimental learning:

1. Model making of Extrusion process setup.

Applications: Plastic products used in day-to-day life.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=k7lb-w7o06s
2. https://www.youtube.com/watch?v=iUH_EdNNtDU
3. https://www.youtube.com/watch?v=SoTfSOFj6q0
4. https://nptel.ac.in/courses/112/107/112107221/

Module-3	RBT Level L1, L2, L3	08 Hrs.

Rotational Moulding: Basic principle, charge size, wall thickness, temperature control, fault causes,

Blow Moulding: Blow moulding process, processing parameter, materials used, hand operated and automatic blow moulding machine, extrusion blow moulding, moulding cycle, faults and remedies.

Thermo Forming: Basic principles, types of thermoforming, thermoforming moulds, processing parameters, faults and remedies.

Laboratory Sessions/ Experimental learning:

1. Model making using blow moulding, rotational and thermo forming processes.

Applications: Household and industrial applications

Video link / Additional online information:

1. https://www.youtube.com/watch?v=Qr5qIMvJSnw
2. https://www.youtube.com/watch?v=8W6P5KU5ONQ
3. https://www.youtube.com/watch?v=alq3RDZN4jo
4. https://nptel.ac.in/courses/112/107/112107221/

Module-4	RBT Level L1, L2, L3	08 Hrs.

Calendaring: Basic principle, process variable, end product properties and applications, secondary processing techniques like powder coating, casting, machining, and joining of plastics, metalizing, printing.

Compression and Transfer Moulding: Techniques, various types of compression moulds, machinery used, and common moulding faults and remedies. Transfer moulding, its advantage over compression moulding, equipment used, press Capacity, integral mold, and auxiliary mould, moulding cycle, ram pressure, clamping pressure, faults and remedies.

Laboratory Sessions/ Experimental learning:

1. Making models using calendering, compression and transfer moulding processes.

Applications: Plastic components used in piping industries/applications.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=pOGpXZ-UMfo
2. https://www.manufacturingguide.com/en/calendering
3. https://www.youtube.com/watch?v=2DUB9DoIoi8
4. https://nptel.ac.in/courses/112/107/112107221/

Module-5	RBT Level L1, L2, L3	08 Hrs.

Processing of Engineering Plastics: precautions, and start up procedure, preheating, shutdown procedure, quality control, and waste management. Ram Extrusion of PTFE, Processing of reinforced plastics, like filament winding, Hand-lay-up, spray moulding, SMC, DMC, Centrifugal casting, pultrusion, resin transfer moulding

Laboratory Sessions/ Experimental learning:

1. Model making of Engineering Plastics.

Applications: Plastic products used in engineering applications

Video link / Additional online information:

1. https://nptel.ac.in/courses/112/107/112107221/
2. https://www.youtube.com/watch?v=qn16JtE_vLc
3. https://www.youtube.com/watch?v=tvk2yWh0cco
4. https://www.youtube.com/watch?v=_m29-u37TI8

Course outcomes:

CO1	understanding of plastic processing and Injection Moulding.
CO2	Understand the principle of extrusion process.
CO3	Understanding of Rotation, blow moulding and thermo forming.
CO4	To describe the methods of Calendering, Compression and transfer moulding.
CO5	Understand the processing of engineering plastics.

Text Books:

1.	**Rubin. J. Irvin,** "Injection Moulding Theory & Practice" , New York John Wiley & Sons.

Reference Books:

1.	Rosato, D., Rosato, A., DiMattia, D "Blow Moulding Hand Book", New York-Oxford University- Hanser Publishers.
2.	Paul F. Bruins "Basic Principles of Rotational Moulding Process", Gordon and Breach Publishers, 1971

CIE Assessment:

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

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

SEE Assessment:

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

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

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

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	SMART MATERIALS AND STRUCTURES	Semester	VI
Course Code	MVJ20ME633	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- Introduce smart materials, piezoelectric materials structures and its characteristics.
- Learn smart structures and modelling which helps in Vibration control for various applications.

Module-1	**RBT Level** L1, L2, L3	08 Hrs.

Introduction: Definition of Structures, Overview of Smart materials, Introduction of Smart Structures, Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect, Processing and characteristics.

Shape Memory Alloys: Introduction, Phenomenology, and Influence of stress on characteristic temperatures, Modelling of shape memory effect. Vibration control through shape memory alloys. Design considerations, multiplexing embedded NiTiNOL actuators.

Laboratory Sessions/ Experimental learning:

- Model making of Piezo based sensor.
- Model to demonstrate shape memory effect.
- Model making of Actuators.

Applications: Sensors and actuators used in automation.

Video link / Additional online information:

https://www.youtube.com/watch?v=QYp9rIJRM8s

Module-2	**RBT Level** L1, L2, L3	08 Hrs.

Vibration Absorbers: Introduction, Parallel Damped Vibration Absorber, Analysis, Gyroscopic Vibration absorbers, analysis & experimental set up and observations, Active Vibration absorbers. Control of Structures: Introduction, Structures as control plants, Modelling structures for control, Control strategies and Limitations.

Biomimetics: Characteristics of Natural structures. Fibre reinforced: organic matrix natural composites, Natural creamers, Biomimetic sensing, Challenges and opportunities.

Laboratory Sessions/ Experimental learning:

2. Model making of Vibration absorber using waste Rubber

Applications*:* Damping of industrial machines or structures.

Video link / Additional online information:

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

Module-3	RBT Level L1, L2, L3	08 Hrs.

Electro rheological and Magneto rheological Fluids: Mechanisms and Properties, Characteristics, Fluid composition and behaviour, Discovery and Early developments, Summary of material properties. Applications of ER and MR fluids (Clutches, Dampers, others).

Fibre Optics: Introduction, Physical Phenomenon, Characteristics, Fibre optic strain sensors.

Laboratory Sessions/ Experimental learning:

- Model making of ER/MR fluid damper

Applications: Automobiles and military vehicles

Video link / Additional online information :

https://www.youtube.com/watch?v=eOSaIJY7AKo

Module-4	RBT Level L1, L2, L3	08 Hrs.

MEMS: History of MEMS, Intrinsic Characteristics, Devices: Sensors and Actuators. ***Microfabrication***: Photolithography, Thermal oxidation, Thin film deposition, etching types, Doping, Dicing, Bonding. Microelectronics fabrication process flow, Silicon based, Process selection and design.

Piezoelectric Sensing and Actuation: Introduction, Cantilever Piezoelectric actuator model, Properties of Piezoelectric materials, Applications. Magnetic Actuation: Concepts and Principles.

Laboratory Sessions/ Experimental learning:

- Model making of magnetic actuator

Applications: Sensors and actuators used in robotics.

Video link / Additional online information:

https://www.youtube.com/watch?v=CNmk-SeM0ZI

Module-5	RBT Level L1, L2, L3	08 Hrs.

Polymer MEMS & Microfluidics: Introduction, Polymers in MEMS (Polyimide, SU-8, LCP, PDMS, PMMA, Parylene, Others) Applications (Acceleration, Pressure, Flow, Tactile sensors). Motivation for micro fluidics.

Case Studies: MEMS Magnetic actuators, BP sensors, Microphone, Acceleration sensors, Gyro, MEMS Product development: Performance, Accuracy, Repeatability, Reliability, Managing cost, Market uncertainties, Investment and competition.

Laboratory Sessions/ Experimental learning:

- Model making of Polymer based MEMS.

Applications: MEMS devices

Video link / Additional online information :

https://www.youtube.com/watch?v=H7qtR5hlIXo

Course outcomes:	
CO1	Understand various smart materials and its properties.
CO2	Identify different vibration absorbers and its applications.
CO3	Explain the principle concepts of Smart materials, structures, Fibre optics, ER & MR Fluids, Biomimetics and MEMS with principles of working.
CO4	To describe the methods of controlling vibration using smart systems and fabrication methods of MEMS.
CO5	Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication.

Text Books:	
1.	A.V.Srinivasan, "*Smart Structures –Analysis and Design*", Cambridge University Press, New York, 2001, (ISBN:0521650267).
Reference Books:	
2.	M.V.Gandhi and B.S.Thompson, "*Smart Materials and Structures*" Chapmen & Hall, London, 1992 (ISBN:0412370107)
3.	Chang Liu "*Foundation of MEMS*", Pearson Education. (ISBN:9788131764756)

CIE Assessment:

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

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

SEE Assessment:

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

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

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

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

High-3, Medium-2, Low-1

Course Title	FINITE ELEMENT METHOD	Semester	VI
Course Code	MVJ20ME634	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	3 Hrs

Course objective is to:

- To learn basic principles and methodologies of finite element analysis.
- To understand the theory and characteristics of finite elements used in analysis of complexed engineering problems.
- To introduce formulation of engineering problems into FEM by discretization process, polynomial, interpolation, application of boundary conditions, assembly of global arrays, solution of the resulting algebraic systems.
- To apply finite element solutions to structural, thermal, dynamic problems to develop the knowledge and skills needed to effectively evaluate finite element analysis.

Module-1	RBT Level L1, L2	08 Hrs.

Pre-requisites: Mechanics of Materials, Engineering Mathematics.

Introduction to Finite Element Method: General description of the finite element method, Steps involved in FEM, Engineering applications of finite element method. Discretization process, Types of elements: 1D, 2D and 3D, Node numbering, Location of nodes. Convergence criteria.

Finite Element Formulation method: Galerkin's method, Potential energy method, Rayleigh Ritz method, Convergence criteria, Discretisation process, Displacement method of finite element formulation.

Basic Procedures: Force terms: Body force, Traction force and point loads, Equilibrium equations, Strain displacement relations, Stress strain relations, Plain stress and Plain strain conditions.

Introduction to Boundary conditions in FEM: Homogeneous and non-homogeneous boundary conditions for structural, heat transfer and fluid flow problems.

Laboratory Sessions/ Experimental learning:

- Develop a Matlab code for imposition of boundary conditions using penalty and elimination approach.

Applications: Stress analysis in solids and automotive design.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=KR74TQesUoQ
2. https://www.youtube.com/watch?v=LCTp7H6Tb8w

3. https://ocw.mit.edu/courses/mechanical-engineering/2-092-finite-element-analysis-of-solids-and-fluids-i-fall-2009/lecture-notes/
4. http://mech.iust.ac.ir/files/mech/madoliat_bcc09/pdf/yijun_liu___nummeth_20040121_fem.pdf

Module-2	RBT Level L1, L2	08 Hrs.

Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of global coordinates, Linear interpolation polynomials in terms of local coordinates for 1D, 2D elements, Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Constant Strain Triangle (CST), Four-Nodded Tetrahedral Element, Eight-Nodded Hexahedral Element, Iso, Super and Sub parametric elements.

Numerical integration: Gaussian quadrature: one point, two-point formulae, 2D integrals.

Interpolation and Polynomial approximation: Interpolation – Linear Regression, Lagrange interpolation functions and approximation methods.

Laboratory Sessions/ Experimental learning:

- Develop a Matlab code for performing numerical integration on single and double variable equations.

Applications: Structural analysis of aircraft wing.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=pCSpBYfbYYA
2. https://nptel.ac.in/courses/112/104/112104115/
3. https://www.youtube.com/watch?v=em1JdaEGXaQ
4. https://www.youtube.com/watch?v=JphRVN9Eezc

Module-3	RBT Level L1, L2, L3	08 Hrs.

Analysis of Bars: Stiffness matrix formulation for bar element, Solution for displacements, stress and strain in 1D straight bars, stepped bars and tapered bars using elimination approach and penalty approach. Temperature effects.

Trusses: Stiffness matrix formulation for truss element, load vector, Solution for truss members.

Torsion of Shafts: Finite Element Analysis of shafts, determination of stress and twists in circular shafts.

Beams: Boundary conditions, Load vector, Hermite shape functions, Beam stiffness matrix based on Euler-Bernoulli beam theory, Examples on cantilever beams, propped cantilever beams, Numerical problems on simply supported, fixed straight and stepped beams using direct stiffness method with concentrated and uniformly distributed load.

Laboratory Sessions/ Experimental learning:

- Stress analysis of bar of constant and tapered cross section area.

- Structural analysis of stepped bar.
- Finite element analysis of beam and truss.

Applications: Structural analysis of a bridge.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=MldJ6WHCsvQ
2. https://www.youtube.com/watch?v=UsMyQ7yPHk8
3. https://nptel.ac.in/courses/112/104/112104193/
4. https://www.youtube.com/watch?v=yfyElneBW98

Module-4	RBT Level L1, L2, L3	08 Hrs.

Heat Transfer: Basic equations of heat transfer: Energy balance equation, Rate equation: conduction, convection, radiation, energy generated in solid, energy stored in solid, 1D finite element formulation using vibrational method, Problems with temperature gradient and heat fluxes, heat transfer in composite sections, straight fins.

Fluid flow analysis: Introduction to Computational Fluid Dynamics (CFD), Computational analysis of flow through uniform, tapered and stepped pipes, porous medium, channels and hydraulic networks.

Laboratory Sessions/ Experimental learning:

- Develop a FE Matlab program for solving steady-state and transient temperature distribution and heat loss through 2D-fin.

Applications: Structural analysis of an advertising roof sign subject to pressure loads from 120km/h winds.

Video link / Additional online information:

1. https://youtu.be/l8t-7-pODN4?list=PLbMVogVj5nJRjnZA9oryBmDdUNe7lbnB0
2. http://www.nptelvideos.in/2012/11/finite-element-analysis.html
3. https://www.youtube.com/watch?v=9MddG4RqOqU
4. https://www.youtube.com/watch?v=DYTg71UACfI

Module-5	RBT Level L1, L2, L3	08 Hrs.

Axis-Symmetric Solid Elements: Derivation of stiffness matrix of axisymmetric bodies with triangular elements, Numerical solution of axisymmetric triangular element(s) subjected to point loads.

Dynamic Analysis: Formulation of finite element model, element - Mass matrices, evaluation of Eigen values and Eigen vectors for a stepped bar, truss and beam.

Finite element – formulation to 3 D problems in stress analysis, convergence requirements, mesh generation techniques, and introduction to fully automatic use of Finite Element Software packages like ANSYS, NISA, and LS DYNA etc.

Laboratory Sessions/ Experimental learning:

- Static structural analysis of plates and axisymmetric problems.
- Modal analysis of bar and beam.

Applications: Structural analysis of a structure subject to gyroscopic dynamic effects.

Video link / Additional online information:

1. https://youtu.be/_iB21ry4tj0?list=PLA4CBD0C55B9C3878
2. http://www.nptelvideos.in/2012/12/introduction-to-finite-element-method.html
3. https://www.youtube.com/watch?v=6LrjKsg2iI0
4. https://www.youtube.com/watch?v=7dKIdPB9bJM

Course outcomes:

CO1	Recognize the importance of FEM and its concepts for real time applications.
CO2	Analyse different variational methods to solve the problem
CO3	Understand use of FEA in Structural and thermal problem
CO4	Learn how to do analysis and learn the various concepts and types of analysis
CO5	Learn finite element modelling techniques.

Text Books:

1	Rao, S. S., *"Finite Element Method In Engineering"*, 5th Edition, Pergaman Int. Library of Science, 2010.

Reference Books:

1.	Logan, D. L., *"A First Course In The Finite Element Method"*, 6th Edition, Cengage Learning, 2016.
2.	Chandrupatla T. R., *"Finite Elements in Engineering"*, 2nd Edition, PHI, 2013.

CIE Assessment:

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

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

SEE Assessment:

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

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

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

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

High-3, Medium-2, Low-1

Course Title	DESIGN OF EXPERIMENTS	Semester	VI
Course Code	MVJ20ME641	CIE	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	SEE	50
No. of Contact Hours/week	3	Total	100
Credits	3	Exam. Duration	3 Hrs

Course objective is to:

- Understand the significance of Design of Experiments in Research.
- Develop the optimization models for the experiments.
- Apply the concepts of optimization in their project work.

Module-1	RBT LEVEL L1, L2	08 Hrs.

Introduction – Principles of optimization, Formulation of objective function, design constraints- classification of optimization problems. Single variable unconstraint optimization – Boundary phase method- Fibonacci search method- Golden section search method – Newton – Raphson method.

Laboratory Sessions/ Experiential learning:

- Demonstration of classical optimization techniques in open source software packages.

Applications: Optimization of the set of experiments for practical conduction.

Video link: https://www.youtube.com/watch?v=p5I_vRPyUc0

Module-2	RBT LEVEL L1, L2	08 Hrs.

Multi variable unconstraint optimization- classical method-Optimization with Equality and Inequality constraints Simplex search method– Conjugate gradient method – Variable-metric method. (Applications of these techniques in Design problems).

Laboratory Sessions/ Experiential learning:

- Developing a multi variable unconstrained model for optimization.

Applications: Design of Experiments for optimization of the process parameters.

Video link: https://www.youtube.com/watch?v=qzXPaWI-BzM

Module-3	RBT LEVEL L1, L2	08 Hrs.

Multi variable constraint optimization: Lagrange's multipliers - Kuhn-Tucker conditions – Penalty function method – Frank-Wolfe method– Generalized projection method. (Applications of these techniques in Design problems).

Laboratory Sessions/ Experiential learning:

- Developing a multi variable constrained model for optimization.

Applications: DOE for the FMCG industry during its product development phase

Video link: https://www.youtube.com/watch?v=niEtQin_D30

Module-4	RBT LEVEL L1, L2, L3	08 Hrs.

Multi objective optimization: Conjugate gradient method - reduced Conjugate gradient method– Newton – Raphson method (Applications of these techniques in Design problems) Integer Programming – Branch and bound method, Introduction to Geometric programming and Dynamic programming.

Laboratory Sessions/ Experiential learning:

- Studying the multi objective optimization techniques for dynamic programming.

Applications: Multiple criteria decision making

Video link: https://www.youtube.com/watch?v=Hm2LK4vJzRw

Module-5	RBT LEVEL L1, L2, L3	08 Hrs.

Stochastic method: Genetic algorithms (GAs): working principle – difference between GAs and traditional methods – GAs for constrained optimization – Simulated annealing- Ant colony algorithm.

Laboratory Sessions/ Experiential learning:

Demonstration of the Genetic Algorithms in MATLAB/Open Source Software packages.

Applications: Stochastic methods for process optimizations.

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

Course Outcomes:

CO1	Explain energy sources such as fuels, flowing water, wind, ocean, tides, waves, geochemical, nuclear energy and Analyze the load estimation, use factor and demand factor.
CO2	Summarize the working principle of Hydro-electric power plant and different types of stokers and oil burners in thermal power plant.
CO3	Explain generation of steam by using high pressure boilers and solve height and efficiency of Chimney.
CO4	Explain Steam Generator Accessories, Method of starting Diesel Engine to generate power, Cooling and Lubrication System and Layout of diesel Power plant.
CO5	Define the Principles of Release in Nuclear Energy and Explain different types of nuclear Reactors.

Text Books:	
1.	**Arora& S Domkundwar, AV Domkundwar**, "A course in Power Plant Engineering", Dhanpatrai & co. Pvt.ltd.2014, ISBN:9788177001075
2.	**P. K. Nag**, "Power Plant Engineering" Tata McGraw Hill, INDIA 4TH edition. 2014, ISBN:9789339204044
Reference Books:	
1.	**F.T. Morse**, "Power Plant Engineering", G. Van Nostrand. 3rd edition 1953, ISBN:9780442055561
2.	**Barrows**, Water power Engineering, TMH, New Delhi, 3rd edition, 1998
3.	**Stanierr,** Plant Engineering, Hand Book, McGraw Hill. 1998
4.	**JagadishLal,** "Hydraulic Machines" Metropollitan Book Co. Pvt Ltd., 1994.ISBN: 9788120000261

CIE Assessment:

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- Quizzes/mini tests (4 marks)
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SEE Assessment:

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

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

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	COMPUTER INTEGRATED MANUFACTURING	Semester	VI
Course Code	MVJ20ME642	**CIE**	50
Total No. of Contact Hours	40 L: T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	3Hrs

Course objective is to:

- To impart knowledge of CIM and Automation and different concepts of automation by developing mathematical models.
- The students will get the knowledge of high-quality production, the manufacturing and assembly line balancing and computerized manufacturing planning system.
- To expose the students to CNC Machine Tools, CNC part programming
- To impart the knowledge of computer aided quality control and shop floor control will help the students to compete with the present technology.

Module-1	RBT Level L1,L2	08 Hrs.

Computer Integrated Manufacturing System & High Volume Production System: Introduction, Production concepts, Mathematical Models, Production economics, Costs in manufacturing, Break even analysis, Unit cost of production, Cost of MLT and WIP. Automated flow lines, work part Transport, Transfer Mechanism and Buffer Storage.

Laboratory Sessions/ Experimental learning:

- Making manufacturing operations readily scalable for different levels of output. Allowing customization and reconfiguration of manufacturing processes with minimal downtime and cost.

Applications: Production planning and control in Manufacturing Industries, Statistical Quality control in production Industries

Video link / Additional online information:

https://nptel.ac.in/content/storage2/112/104/112104288/MP4/mod01lec03.mp4

https://nptel.ac.in/content/storage2/MP4/112104289/mod01lec01.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod01lec02.mp4

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

Module-2	RBT Level L2, L3	08 Hrs.

Analysis of Automated Flow line and Line Balancing: Analysis of Transfer Lines without storage and with storage, Partial Automation, Manual Assembly Lines, Methods of Line balancing, Computerized Line Balancing. Automated Material Handling System, Automated guided vehicle system.

Laboratory Sessions/ Experimental learning:

- Providing management with detailed and timely information about the manufacturing process. Enabling manufacturers to coordinate their work processes with those of their suppliers and customers to maximize efficiency and minimize costs.

Applications: Automated flow line control and line balancing

Video link / Additional online information:

https://www.youtube.com/watch?v=9fqygvj-O2s

https://nptel.ac.in/content/storage2/112/104/112104288/MP4/mod01lec05.mp4

https://nptel.ac.in/content/storage2/112/104/112104288/MP4/mod01lec04.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec48.mp4

Module-3	RBT Level L2, L3	08 Hrs.

Computerized Manufacturing Planning System and Flexible Manufacturing Systems: Computer Aided Process Planning: retrieval types, Generative type, Material Requirement Planning, Fundamental concepts of MRP, Inputs to MRP, Capacity Planning. Group technology. Flexible Manufacturing Systems, types of FMS, FMS components.

Laboratory Sessions/ Experimental learning:

- Integration of automated assignment and reporting of factory floor operations through machine and material handling equipment sensors and software

Applications: Flexible manufacturing system in production industries.

Video link / Additional online information

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod06lec26.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod07lec28.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod07lec29.mp4

https://www.youtube.com/watch?v=20_K7c65Swg

Module-4	RBT Level L2, L3	08 Hrs.

CNC Machining Centers: Introduction to CNC, elements of CNC, CNC machining centers, part programming, fundamental steps involved in development of part programming for milling and turning. Programming with canned cycles. Cutter radius compensations.

Shop Floor Control & Computer Aided Quality Control: Factory, Data Collection System, Automatic identification system. Inspection methods, Non-Contact inspection methods, Co-ordinate measuring machine

Laboratory Sessions/ Experimental learning:

- Apply data insights to upgrade quality and lower inspection costs. Achieving a highly automated manufacturing process with rigorous computerized monitoring and management of quality and productivity.

Applications: CNC Machine Tools, CNC part programming, Quality control and Processing.

Video link / Additional online information:

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod03lec12.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod03lec13.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod03lec14.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec49.mp4

Module-5	RBT Level L2, L3	08 Hrs.

Future of Automated Factory: Industry 4.0, functions, applications and benefits. Components of Industry 4.0, Internet of Things (IOT), IOT applications in manufacturing, Big-Data and Cloud Computing for IOT, IOT for smart manufacturing, influence of IOT on predictive maintenance, industrial automation, Introduction to Industrial Internet of things (IIOT), supply chain optimization, supply-chain and logistics, cyber-physical manufacturing systems.

Laboratory Sessions/ Experimental learning:

- Use IoT and plant-floor data to predict and prevent equipment failure improve reliability and reduce downtime. Better use of capital resources through work automation.

Applications: Smart Appliances, Smart energy meters, Wearable devices.

Video link / Additional online information:

https://youtube/WUYAjxnwjU4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec48.mp4

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec49.mp4

Course Outcomes:	
CO1	Able to define Automation, CIM, CAD, CAM and explain the differences between these concepts.
CO2	Explain the basics of automated manufacturing industries through mathematical models and analyse different types of automated flow lines.
CO3	Analyse the automated flow lines to reduce down time and enhance productivity.
CO4	Explain the use of different computer applications in Shop Floor Control & computer aided quality control, and able to prepare part programs for simple jobs on CNC machine tools.
CO5	Visualize and appreciate the modern trends in Manufacturing like additive manufacturing, Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

Text Books:	
1.	Mikell P Groover, "*Automation, Production Systems and Computer-Integrated Manufacturing*", 4th Edition, 2015, Pearson Learning.
2.	P N Rao "*CAD / CAM Principles and Applications*", 3rd Edition, 2015, Tata McGraw-Hill.
Reference Books:	
1	P. Radhakrishnan, "*CAD/CAM/CIM*" 3rd edition, New Age International Publishers, New Delhi.
2.	Arshdeep Bahga and Vijay Madisetti, "*Internet of Things: A Hands-on Approach*", (Universities Press).

CIE Assessment:

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

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

SEE Assessment:

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

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

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

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

High-3, Medium-2, Low-1

Course Title	MATERIAL CHARACTERISATION TECHNIQUES	Semester	VI
Course Code	MVJ20ME643	**CIE**	50
Total No. of Contact Hours	40 L: T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	3 Hrs

Course objective is to:

- Introduce the students to the principles of optical and electron microscopy, X-ray diffraction and various spectroscopic techniques.
- Introduce the students to the importance of materials characterization and its need for real-time applications.
- Enable the students to understand the vacuum systems and the application of cryogenics for materials characterization.

Module-1	**RBT Level** L1, L2	08 Hrs.

Introduction to materials and methods, Fundamentals of Materials Characterization, Basic operation, sample preparation and interpretation of data. Basic failure analysis of materials using different characterization equipment. Importance of Material characterization, Classification of techniques for characterization.

Laboratory Sessions/ Experimental learning:

- Demonstration of the simple material characterization tests in material testing lab.

Applications: Tensile testing and Compression testing of the materials.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=8YflxVwm6cE
2. https://www.youtube.com/watch?v=nSuHuaNT8kE
3. https://www.youtube.com/watch?v=TnT7vXpsn6E
4. https://www.youtube.com/watch?v=y_1XFssBsGI

Module-2	**RBT Level** L1, L2	08 Hrs.

Vacuum systems: Vacuum range, Vacuum Pumps: Rotary, Sorption, Turbomolecular, Diffusion, Ion, Cryogenic systems. Vacuum measurement gauge: Pirani, Penning, Ionization etc. Use of Vacuum systems in Material Characterization techniques.

Thermal Analysis techniques: Principle, Working and application of DTA, TGA, TMA and DSC

Laboratory Sessions/ Experimental learning:

- Demonstration of thermogravimetric characterization techniques and its relevance through audio visuals.

Applications: Thermal characterization of the composites.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=mC0rYNlMz9Q
2. https://www.youtube.com/watch?v=QHMzFUo0NL8
3. https://www.youtube.com/watch?v=W_KO3ahVu4s
4. https://www.youtube.com/watch?v=CXmnvvoi4yA

Module-3	RBT Level L1, L2	08 Hrs.

Optical microscopy techniques: Metallurgical Microscopes, Aberration in Optical microscopy & its remedies, Polarized light in microscopy, Differential Interference Contrast Illumination, Hot Stage Microscopy, colour metallography, and image analysis techniques.

Electron microscopy: Electron beam. Principle, Construction and Working of TEM, SEM, STEM, with their merits, limitations and applications.

Laboratory Sessions/ Experimental learning:

- Activities with respect to microstructural characterization using optical microscopy in materials testing lab to help students gain more knowledge about microstructure will be carried out.

Applications: Microstructural characterization of the composites.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=VR9d6RnmZww
2. https://www.youtube.com/watch?v=CVusz4wHaic
3. https://www.youtube.com/watch?v=fuy0-yT8INU
4. https://www.youtube.com/watch?v=NG44AEWHtRQ

Module-4	RBT Level L1, L2	08 Hrs.

Atomic Microscopy: Field Ion Microscope, Working of AFM and STM with their merits, limitations and applications.

Spectroscopic Techniques for chemical analysis: UV-Visual (UV-VIS), IR, FTIR, & EDS, X-ray Fluoroscopy (XRF), Atomic absorption spectrometer (AAS), Atomic Emission spectroscopy (AES).

Laboratory Sessions/ Experimental learning:

- Activities related to the understanding of the significance of characterization of atomic arrangement of materials and its influence on properties of the materials will be demonstrated.

Applications: Spectroscopic characterization of the materials chemical analysis and morphological characterization.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=xnOqahYA6NU
2. https://www.youtube.com/watch?v=FQzUrbKTLVU
3. https://www.youtube.com/watch?v=GY9lfO-tVfE
4. https://www.youtube.com/watch?v=8TaXtCOZV4o

Module-5	RBT Level L1, L2	08 Hrs.

Diffraction method: Brags Law, X-ray diffraction methods, determination of crystal structure, lattice parameter, crystallite size, merits and demerits. Surface characterization: XPS (ESCA), UPS, Auger Electron Spectroscopy, Electron Probe Micro Analysis (EPMA).

Laboratory Sessions/ Experimental learning:

- Demonstration of the XRD techniques for phase characterization of the materials through audio visuals.

Applications: Characterization of the materials for crystal structure, phase, preferred crystal orientation (texture), and other structural parameters, such as average grain size, crystallinity, strain, and crystal defects.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=Z5aCuGxUPpI
2. https://www.youtube.com/watch?v=07iZ7-IEyYE
3. https://www.youtube.com/watch?v=lwV5WCBh9a0
4. https://www.youtube.com/watch?v=AqCz_b7VJK8

Laboratory Sessions

Design based Problems (DP)/Open Ended Problem:

1. Chart of different vacuum systems.
2. Chart of different thermal Analysis techniques.
3. Chart of different Optical microscopy techniques.
4. Chart of different electron and atom microscopy techniques.
5. Chart of different Spectroscopic Techniques for chemical analysis.
6. Problems based on brag's law.
7. Chart of different X-ray diffraction methods.
8. Chart of different Surface characterization techniques.
9. Collection and Study of various samples of coated & surface treated-materials, new alloys etc.
10. Group discussion and Presentations on Recent trend in material characterization.
11. Any other problem decided by faculty based on syllabus.

Course outcomes:	
CO1	Explain importance & Classification of Characterization Techniques.
CO2	Describe use of Vacuum systems in Material Characterization techniques & explain working of Thermal Analysis techniques.
CO3	Describe the principal and methods of different optical microscopy techniques for observation of Microstructure & Describe the principal and methods of different electron microscopy techniques.
CO4	Describe the principal and methods of different atom microscopy techniques & Explain Chemical & Elemental Analysis for a given engineering application.
CO5	Explain identification techniques of crystal structure, lattice parameter & crystallite size of different materials using X-ray diffraction & understand and explain surface morphologies of different Materials including coated & surface treated-materials, new alloys etc.

Text Books:	
1.	F. Weinberg, *"Tools & Techniques in Physical Metallurgy"*, Vol. I & II, Marcel Dekker.
2.	John P. Sibilia, *"A guide to Material Characterization & Chemical Analysis"*, VCH Publishers, 1988.
3.	J.M. Walls, *"Methods of Surface Analysis: Techniques & Applications"*, Cambridge University Press, 1990.
Reference Books:	
1.	B.D. Cullity, *"Elements of X-ray diffraction"*, Addison-Wesley Publishing Company, INC,.
2.	Bernhard Wounderlich, *"Thermal Analysis"*, Academic Press, INC, 1990.
3.	B.L. Gabriel, *"SEM: A user's manual for materials Science"*, American Society for Metals
4.	P. R. Khangaonkar *"An Introduction to Materials Characterization"*, Penram International Publishing (India) Pvt. Ltd.
	List of Open-Source Software/learning website:
1.	https://www.aif.ncsu.edu/mct/
2.	https://www.vssut.ac.in/lecture_notes/lecture1429901637.pdf
3.	https://www.researchgate.net/publication/327732057_Handbook_of_Materials_Characterization

CIE Assessment:

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

SEE Assessment:

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

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

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

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

High-3, Medium-2, Low-1

Course Title	THEORY OF ELASTICITY	Semester	VI
Course Code	MVJ20ME644	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3 : 0 : 0	SEE	50
No. of Contact Hours/week	04	Total	100
Credits	03	Exam. Duration	03 Hrs

Course objective is to:

- Gain knowledge of stresses and strains in 3D and their relations and thermal stresses.
- Understand the 2D analysis of elastic structural members.
- Analysis elastic members for the stresses and strains induced under direct loading conditions.
- Analyse the thermal stresses induced in disks and cylinders.

Module-1	RBT Level-L1,L2,L3	08Hrs.

Analysis of Stress: Definition and Notation for forces and stresses. Body force, surface force Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses maximum and minimum shear stress.

Mohr's Circle Diagram

Mohr's diagram in three dimensions. Boundary conditions. Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress, deviator and spherical stress tensors, Stress transformation, Numericals.

Laboratory Sessions/ Experimental learning: conduction of Mohr's test for ductile materials.

Video link:

https://nptel.ac.in/courses/112/102/112102284/

Module-2	RBT Level-L1,L2,L3	08Hrs.

Deformation and Strain: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, strain invariants, Strain transformation

Compatibility equations: Cubical dilatation, spherical and deviator strains, plane strain, Mohr's circle, and compatibility equation, Numericals.

Laboratory Sessions/ Experimental learning: Analyzing the different materials for their yielding stresses and strains using photo elasticity.

Video link:

https://www.youtube.com/watch?v=eICv1p8WjgI&list=PLbRMhDVUMngcbhsZgRWuYCi2kKQwQ0Av1

Module-3	RBT Level- L1, L2,L3	08Hrs.
Two Dimensional Problems in Cartesian Co-Ordinates: Airy's stress function, investigation of simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load. Use of Fourier series to solve two dimensional problems. Existence and uniqueness of solution, Saint -Venant's principle, Principle of super position and reciprocal theorem **Laboratory Sessions/ Experimental learning:** Analyzing the different materials for their yielding stresses and strains using photo elasticity. **Video link:** https: www.youtube.com/watch?v=YpOy_z2oRDc&list=PL0bRAs68fCS310qm-k2ccRa6fZTc0kxCR		
Module-4	RBT Level- L1,L2.L4	08Hrs.
Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, Strain components in polar co-ordinates, Rotating disk and cylinder, Concentrated force on semi-infinite plane, Stress concentration around a circular hole in an infinite plate. **Laboratory Sessions/ Experimental learning:** Analyzing the different materials for their yielding stresses and strains using photo elasticity. **Video link:** https: www.youtube.com/watch?v=YpOy_z2oRDc&list=PL0bRAs68fCS310qm-k2ccRa6fZTc0kxCR		
Module-5	RBT Level- L3,L4,L5	08Hrs.
Relations and the General Equations of Elasticity: Generalized Hooke's law in terms of engineering constants. Formulation of elasticity Problems. **Thermal Stresses:** Introduction, Thermo-elastic stress -strain relations, thin circular disc, long circular cylinder. **Laboratory Sessions/ Experimental learning**: Analyzing the different materials for their thermal stresses and strains. **Video link:** https: www.youtube.com/watch?v=YpOy_z2oRDc&list=PL0bRAs68fCS310qm-k2ccRa6fZTc0kxCR		

Course Outcomes:	
CO1	Describe the state of stress and strain in 2D and 3D elastic members subjected to direct loads and thermal loads.
CO2	Analyse the structural members: beam, rotating disks, columns
CO3	Analyse the thermal stresses induced in disks and cylinders.

Text Books:	
1.	Timoshenko and Goodier, "Theory of Elasticity"-'Tata McGraw Hill, New Delhi,3rd edition , 1970.
Reference Books:	
1.	L S Srinath "Advanced Mechanics of Solids"- Tata McGraw Hill, New Delhi, 3rd edition, 2010
2.	G. Thomas Mase, Ronald E. Smelser, George. E. Mase, Continuum Mechanics for Engineers, 3rd Edition, CRC Press,Boca Raton, 2010.

CIE Assessment:

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

SEE Assessment:

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

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

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

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CO1	3	3	1	2	-	-	-	-	2	1	1	1
CO2	3	3	1	2	-	-	-	-	2	1	1	1
CO3	3	3	2	3	-	-	-	-	2	1	2	1

High-3, Medium-2, Low-1

Course Title	AUTOMOTIVE ELECTRONICS	Semester	6
Course Code	1MJ19ME651	**CIE**	50
Total No. of Contact Hours	40 L: T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	3 Hrs

Course objective is to:

- Basics of electronic control of internal combustion engines and the drives
- Understand principle of working of sensors and actuators used in automobiles for control
- To understand functions and operations of sensor
- Understand MEMS and Piezoelectric sensing and actuating
- Diagnostics and safety systems in automobiles.

Module-1	**RBT Level** L1, L2	08 Hrs.

Automotive Fundamentals Overview – Evolution of Automotive Electronics, Automobile Physical Configuration, Survey of Major Automotive Systems, The Engine – Engine Block, Cylinder Head, Four Stroke Cycle.

Ignition System - Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition Timing, Diesel Engine, Drive Train -Transmission, Drive Shaft, Differential, Brakes, Steering System, Starter Battery –Operating principle

Laboratory Sessions/ Experimental learning:

- Building automobile Layout

Applications:

- Car transmissions
  https://www.motorbiscuit.com/4-types-of-car-transmissions-and-how-they-work/

Video link / Additional online information:

- How an engine works - comprehensive tutorial animation featuring Toyota engine technologies.
  https://www.youtube.com/watch?v=zA_19bHxEYg&t=6s
- Coursera
  https://www.coursera.org/lecture/modeling-debugging-embedded-systems/segment-1-automotive-1-WguSX

- Coursera
  https://www.coursera.org/lecture/industrial-iot-markets-security/segment-1-automotive-and-transportation-iQpo1
- Fundamentals of Automotive Systems
  https://onlinecourses.nptel.ac.in/noc20_de06/preview

Module-2	RBT Level L1, L2	08 Hrs.

The Basics of Electronic Engine Control – Motivation for Electronic Engine Control – Exhaust Emissions, Fuel Economy, Concept of an Electronic Engine control system, Definition of General terms, Engine mapping, Effect of Air/Fuel ratio, spark timing and EGR on performance, Electronic Fuel control system, Analysis of intake manifold pressure, Electronic Ignition.

Control Systems - Automotive Control System applications of Sensors and Actuators – Typical Electronic Engine Control System, Variables to be measured.

Laboratory Sessions/ Experimental learning:

- To build an ECU to show its function on fuel injection.

Applications:

- PowerTRONIC ECU on the Royal Enfield Himalayan
  https://www.youtube.com/watch?v=xHQBxG-9V00

Video link / Additional online information:

- Automotive Electronic Modules Types
  https://www.youtube.com/watch?v=BG4N2dBgJrQ
- Coursera
  https://www.coursera.org/lecture/energy-environment-life/how-things-work-the-engine-in-your-car-r7tHF
- Coursera
  https://www.coursera.org/learn/motors-circuits-design
- Introduction to control Systems
  https://nptel.ac.in/courses/107/106/107106081/

Module-3	RBT Level L1, L2, L4	08 Hrs.

Automotive Sensors –Airflow rate sensor, Strain Gauge MAP sensor, Engine Crankshaft Angular Position Sensor, Magnetic Reluctance Position Sensor, Hall effect Position Sensor, Shielded Field Sensor, Optical Crankshaft Position Sensor, Throttle Angle Sensor (TAS), Engine Coolant Temperature (ECT) Sensor, Exhaust Gas Oxygen (O2/EGO), Lambda Sensors, Piezoelectric Knock Sensor. Automotive Actuators– Solenoid, Fuel Injector, EGR Actuator, Ignition.

Laboratory Sessions/ Experimental learning:

- Study on sensor in MMM Lab or Build a small sensor to show its operations / functions useful in automobile applications.

Applications: All automatic switches

- Manifold Absolute Pressure (MAP) Sensor
  https://www.youtube.com/watch?v=bHY7wu45AuU

Video link / Additional online information:

- How car sensors work
  https://www.youtube.com/watch?v=jyQuRgQHGCk
- Coursera
  https://www.coursera.org/specializations/embedding-sensors-motors
- Coursera
  https://www.coursera.org/lecture/internet-of-things-history/iot-automotive-0vJj5

Module-4	RBT Level L1, L2	08 Hrs.

Automotive Diagnostics–Timing Light, Engine Analyzer, On-board diagnostics, Off-board diagnostics, Expert Systems, Occupant Protection Systems – Accelerometer based Air Bag systems. **Future Automotive Electronic Systems** –Alternative Fuel Engines, Collision Avoidance Radar warning Systems, Low tire pressure warning system, Heads Up display, Speech Synthesis, Navigation – Navigation Sensors - Radio Navigation, Signpost navigation, dead reckoning navigation, Voice Recognition Cell Phone dialling, Advanced Cruise Control, Stability Augmentation, Automatic driving Control.

Laboratory Sessions/ Experimental learning:

- Build a model on any one to diagnose.

Applications:

- Vehicle Diagnostics: Off-Board vs On-Board Diagnostics
  https://www.youtube.com/watch?v=RogF0ohkMJ4

Video link / Additional online information:

- Diagnosing with The Lab Scope - Why Every Tech Needs To Be Using This Tool
  https://www.youtube.com/watch?v=cLOFxmEXrWs
- Coursera
  https://www.coursera.org/lecture/arduino/5-13-diagnostics-vm8Ph
- Coursera
  https://www.coursera.org/lecture/modeling-debugging-embedded-systems/segment-2-automotive-2-mezgS

Module-5	RBT Level L3, L4,L5	08 Hrs.

Electrical vehicles- History of electric vehicles, Introductions to electrical vehicles, Configurations of Electric Vehicles, Performance of Electric Vehicles, types of batteries used in Electric Vehicles

Hybrid Electric Vehicles- Concept of Hybrid Electric Drive Trains, Architectures of Hybrid Electric Drive Trains.

Laboratory Sessions/ Experimental learning:

- Build a proto type electrical vehicle

Applications:

- Electrical vehicles
  https://www.youtube.com/watch?v=s9NT_YBqujc

Video link / Additional online information:

- Overview of Electric Vehicles in India
  https://www.youtube.com/watch?v=3E1SXG7VkQk
- Coursera
  https://www.coursera.org/lecture/future-of-energy/electric-vehicles-and-storage-technologies-part-1-UHkV7
- Coursera
  https://www.coursera.org/lecture/electric-utilities/5-5-electric-vehicles-vPV6a
- BMS Design of Electric Vehicle
  https://www.youtube.com/watch?v=cS5tkvbC4ts

Course outcomes:	
CO1	Students will understand basic of automobiles
CO2	Detail idea of electronic and control system in automobiles
CO3	Understand Working / functions of sensors used in automobiles
CO4	To know importance of Automotive diagnostics
CO5	Understand about Electrical Vehicles

Text Books:	
1.	**William B.Ribbens,** "***Understanding Automotive Electronics***", 6th Edition, Elsevier Publishing.
2.	**Robert Bosch Gmbh (Ed.)** "***Bosch Automotive Electrics and Automotive Electronics Systems and Components***", Networking and Hybrid Drive, 5th edition, John Wiley& Sons Inc., 2007.
Reference Books:	
1.	**A.V.Srinivasan**, "***Smart Structures –Analysis and Design***", Cambridge University Press, New York, 2001, (ISBN: 0521650267).
2	**Modern Electric, Hybrid Electric & Fuel Cell Vehicles -** Mehrdad Ehsani

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

SEE Assessment:

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

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

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

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	OPERATION MANAGEMENT	Semester	VI
Course Code	MVJ20ME652	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course objective is to:

- This course will give details about various engineering management system in the production industry.
- To study the about optimistic utility of the available resources like material and time.

Module-1	RBT Level L1,L2	08Hrs.

Production and Operations Management: Introduction, Functions within business organizations, the operation management function, Classification of production systems, Productivity, factors affecting productivity, contemporary issues and development

Decision Making: The decision process, characteristics of operations decisions, use of models, decision making environments, graphical linear programming, analysis and trade-offs.

Video link / Additional online information:

https://nptel.ac.in/courses/110/107/110107141/

Module-2	RBT Level L1,L2	08Hrs.

Forecasting: Steps in forecasting process, approaches to forecasting, forecasts based on judgment and opinion, analysis of time series data, accuracy and control of forecasts, choosing a forecasting technique, elements of a good forecast.

Video link / Additional online information:

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

Capacity & Location Planning: Importance of capacity decisions, defining and measuring capacity, determinants of effective capacity, determining capacity requirement, developing capacity alternatives, evaluating alternatives, Need for location decisions, nature of locations decisions, general procedure for making locations decisions, evaluating locations decisions, facilities layout - need for layout decisions, types of processing.

Video link / Additional online information:

https://www.youtube.com/watch?v=1AN_L_8-x84

Module-3	RBT Level L2,L3	08 Hrs.

Aggregate Planning and Master Scheduling: Aggregate planning - Nature and scope of aggregate planning, strategies of aggregate planning, techniques for aggregate planning - graphical and charting techniques, mathematical techniques. The master production schedule, Master scheduling process, Master scheduling methods.

Video link / Additional online information:

https://www.youtube.com/watch?v=Ic_El2DkpjA

https://www.youtube.com/watch?v=VjSgga4E6VY

Inventory Management: Types of Inventories, independent and dependent demand, reasons for holding inventory, objectives of inventory control, requirements for effective inventory management - information, cost, priority system. Inventory control and economic-order-quantity models.

Video link / Additional online information:

https://www.digimat.in/nptel/courses/video/110105095/L01.html

Module-4	RBT Level L2,L3	08 Hrs.

Material Requirement Planning (MRP): Dependent versus independent demand, an overview of MRP - MRP inputs and outputs, MRP processing, An overview of MRP-II and ERP capacity requirement planning, benefits and limitations of MRP.

Video link / Additional online information:

https://www.youtube.com/watch?v=E4OYh890IRE

Purchasing and Supply Chain Management (SCM): Introduction, Importance of purchasing and SCM, The procurement process, Concept of tenders, Approaches to SCM, Vendor development, Measures of purchasing and SCM, Make or buy decision, Types of buying, E-procurement.

Video link / Additional online information:

https://www.youtube.com/watch?v=Z1zi7fMLmV4

Module-5	RBT Level L1,L2	08Hrs.

Introduction: The Meaning of Quality and Quality Improvement; Brief History of Quality Methodology; Statistical Methods for Quality Control and Improvement; Total Quality Management (quality philosophy, links between quality and productivity, quality costs, legal aspects of quality implementing, quality improvement).

Methods And Philosophy of Statistical Process Control: Chance and assignable causes, Statistical Basis of the Control Charts (basic principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on

control charts, warning limits, Average Run Length-ARL).

Video link / Additional online information:

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

Laboratory Sessions:

- Students can be given the group task assigning some case study related to industry
- Students can be asked as a group to come with the model/flow chart to explain the utility of available resources like material, man power and time.

Course Outcomes:

CO1	Students will be able to acquire the decision making ability in the production industry
CO2	Students will be able to visualise the future industrial demand in terms of product
CO3	Students will be able to control the inventory based on forecasting the demand
CO4	Students will be able to order the material based on the requirement and use it optimistically
CO5	Students will learn the quality tool like various charts to use in the industry

Text Books:

1	William J Stevenson, "*Production and Operations Management*", 9th Ed., Tata McGraw Hill.
2	B Mahadevan "*Operations Management-Theory and Practice*", Pearson Education, 2007.
3	Norman Gaither and Greg Frazier," *Production and Operations Management*".

Reference Books:

1	R.B.Chase, N.J.Aquilino, F. Roberts Jacob "*Operations Management for Competitive Advantage*" McGraw Hill Companies Inc., Ninth Edition.
2	Everett E.Adams, Ronald J.Ebert, "*Production & Operations Management*", Prentice Hall of India Publications, Fourth Edition.
3	Joseph G Monks, "*Production / Operations Management*", McGraw Hill Books.

CIE Assessment:

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

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

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

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

High-3, Medium-2, Low-1

Course Title	ENGINEERING ECONOMICS	Semester	VI
Course Code	MVJ20ME653	**CIE**	50
Total No. of Contact Hours	40 L : T : P :: 3 : 0 : 0	**SEE**	50
No. of Contact Hours/week	04	**Total**	100
Credits	03	**Exam. Duration**	03 Hrs

Course Objectives is to:

- Explain the importance of engineering economics, Law of demand and supply in engineering decision making.
- Describe various interest rate factors and implement the same for economic decision making.
- Discuss different component of costs, methods of cost estimation and different methods of computing depreciation.
- Discuss taxation concepts-income, corporate taxes and financial functions.

Module-1	**RBT Level** L1,L2	08 Hrs.

Introduction: Engineering Decision-Makers, Engineering and Economics, Problem solving and Decision making, Intuition and Analysis, Tactics and Strategy. Engineering Economic Decision. Law of demand and supply, Law of returns, Interest and Interest factors: Interest rate, Simple interest, Compound interest, Cash - flow diagrams, Personal loans and EMI payment calculation with flexible interest rates, Exercises and Discussion.

Laboratory Sessions/ Experimental learning:

- Calculating the EMI for housing loan, auto loan & personal loans for different sectors

Applications: It gives idea to find out EMI costs for various loans, credit cards.

Video link / Additional online information:

http://nptel.ac.in/courses/112107209/

https://nptel.ac.in/courses/110/106/110106135/

https://youtu.be/KnZdHPs04EI

https://youtu.be/vPurJyt3wlE

https://video-tutorial/14539-engineering-economics-video

Module-2	**RBT Level** L2,L3, L4	08 Hrs.

Present-Worth Comparisons: Conditions for present worth comparisons, Basic Present worth comparisons, Present-worth equivalence, Net Present worth, Assets with unequal lives, infinite lives,

Future-worth comparison, Future-worth equivalence, Pay-back comparison, Exercises, Discussions and problems.

Laboratory Sessions/ Experimental learning:

- Finding out the present and future worth comparisons for various assets for economic analysis.

Applications: Compares the present and future worth amount of various loans, products and firms used generally by banks.

Video link / Additional online information:

http://nptel.ac.in/courses/105103023/

https://youtu.be/4rZ-DPszlZE

https://youtu.be/INpZiJOd_OU

https://youtu.be/WphRgFpEq-Y

https://youtu.be/i8BTMqZgqbQ

Module-3	RBT Level L2, L3,L4	08 Hrs.

Equivalent Annual-Worth Comparisons: Equivalent Annual-Worth Comparison methods, Situations for Equivalent Annual-Worth Comparisons, Consideration of asset life, Comparison of assets with equal and unequal lives, Use of shrinking fund method, Annuity contract for guaranteed income, Exercises, Problems.

Laboratory Sessions/ Experimental learning:

- Finding out the annual worth comparisons for various assets for economic analysis.

Applications: It gives idea to know about annual amount of various assets for the financial year.

Video link / Additional online information:

http://nptel.ac.in/courses/105103023/

https://youtu.be/WYbC1-TsGis

https://youtu.be/tTk1-zI_nuM

Module-4	RBT Level L2, L3, L4	08 Hrs.

Costing and Depreciation: Components of costs, estimation of selling price, marginal cost, first cost, all kinds of overheads, indirect cost estimation with depreciation, mensuration and estimation of material cost, cost estimation of mechanical process, idling time. Product costing (approaches to product costing), causes of depreciation, methods of computing depreciation charges, straight line method, declining balance method, sum of years method, sinking fund method, service output methods, taxation concepts, personal income taxes and corporate taxes, Discussions and problems.

Laboratory Sessions/ Experimental learning:

- Estimating the budget for any given project by means of costing and depreciation.

Applications: It is used in banking sector to find out different costs based on periodic time.

Video link / Additional online information:

http://nptel.ac.in/courses/110105067/

https://onlinecourses.nptel.ac.in/noc20_mg53/

https://youtu.be/-i30WCeQ7i8

Module-5	RBT Level L3, L4, L5	08 Hrs.

Introduction, Scope of Finance, Finance Functions: Statements of Financial Information: Introduction, Source of financial information, Financial statements, Balance sheet, Profit and Loss account, relation between Balance sheet and Profit and Loss account. Simple Numericals.

Financial Ratio Analysis: Introduction, Nature of ratio analysis, Liquidity ratios, Leverage ratios, Activity ratios, Profitability ratios, Evaluation of a firm's earning power. Comparative statements analysis. Simple Numerical.

Laboratory Sessions/ Experimental learning:

- Analysis the economy of the country to provide the balance sheet, profit & loss for any financial year resources.

Applications: It gives the clear picture for framing budget for any financial year to announce any scheme and funds from the Government.

Video link / Additional online information:

http://nptel.ac.in/courses/110105067/

https://youtu.be/Sx-dy96_tCQ

https://youtu.be/OqHEseiXcbg

https://youtu.be/9LcbamL2Xas

Course outcomes:

CO1	Understand engineering economics demand supply and its importance in economics decision making and problem solving.
CO2	Calculate present worth, annual worth and IRR for different alternatives in economic decision making.
CO3	Understand the procedure involved in estimation of cost for a simple component, product costing and depreciation, its methods.
CO4	Examine the different economic analysis methods for decision making.
CO5	Understand the procedure of financial statements and balance sheets.

Text Books:	
1.	Riggs J.L, "*Engineering Economy*", 4TH ed. , McGraw Hill, 2002
2.	Thuesen H.G., *"Engineering Economy"*, PHI , 2002
Reference Books:	
1.	Leland Blank & Anthony Tarquin, *"Basics of Engineering Economy"*, McGraw Hill Publication (India) Private Limited.
2.	R.Paneerselvam, *"Engineering Economics"*, PHI publication.

CIE Assessment:

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

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

SEE Assessment:

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

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

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

CO-PO Mapping

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

High-3, Medium-2, Low-1

Course Title	COMPUTER AIDED MODELLING AND ANALYSIS LAB	Semester	VI
Course Code	MVJ20MEL66	CIE	50
Total No. of Contact Hours	20 L: T: P: 0:1: 3	SEE	50
No. of Contact Hours/week	02	Total	100
Credits	02	Exam. Duration	03

Course Learning Objectives:

- Get the basic understanding of Modelling and Analysis software
- To understand the concepts of different kinds of loading on bars, trusses and beams, and analyze the results pertaining to various parameters like stresses and deformations.
- To provide the basic knowledge about the principles of dynamic analysis.

Sl. No	Experiments
	PART A
1	Study of a FEA package and modelling and stress analysis.
2	Analysis of Bars of constant cross section area, tapered cross section area and stepped bar
3	Analysis of Trusses – (Minimum 2 exercises of different types)
4	Analysis of Beams – Simply supported, cantilever, beams with point load, UDL, beams with varying load etc. (Minimum 6 exercises)
5	Stress analysis of a rectangular plate with a circular hole.
6	Demonstration of Static Structural analysis for different boundary conditions.
	PART B
7	Thermal Analysis – 1D & 2D problem with conduction and convection boundary conditions (Minimum 4 exercises of different types)
8	Dynamic Analysis to find: a) Natural frequency of beam with fixed – fixed end condition b) Response of beam with fixed – fixed end conditions subjected to forcing function c) Response of Bar subjected to forcing functions
	PART C (OPTIONAL)
9	Demonstrate the use of graphics standards (IGES, STEP etc) to import the model from modeler to solver.
10	Demonstrate one example of contact analysis to learn the procedure to carry out contact analysis.
11	Demonstrate at least two different types of example to model and analyze bars or plates made from composite material.

Course Outcomes:	
CO1	Apply the concepts of FEM for solving problems on bars, beams and trusses.
CO2	Carry out static analysis to obtain deflection of beams subjected to point, uniformly distributed and varying loads and use the available results to draw shear force and bending moment diagrams.
CO3	Solve 1D and 2D heat transfer conduction and convection problems with different boundary conditions.
CO4	Demonstrate the ability to Carry out dynamic analysis and find natural frequencies of beams, plates, and bars for various boundary conditions.

Reference Books:	
1.	Finite Element Method in Engineering, Rao, S. S, Pergaman Int. Library of Science, 5th Edition 2010.
Scheme of Examination: As per the MVJCE Autonomous Regulations, Semester End Examination (SEE) is to be conducted and evaluated for 100 marks which will be proportionately reduced and considered for 50 marks by the Grading authority.	
1.	One question is to be set from Part-A: 20 marks
2.	One question is to be set from Part-B: 20 Marks
3.	Viva – Voce: 10 marks

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	2	-	-	-	2	-	2	-	2
CO3	3	2	3	1	-	-	-	2	-	1	-	2
CO4	3	3	3	2	-	-	-	2	-	2	-	2
CO5	3	2	1	1	-	-	-	2	-	1	-	1

High-3, Medium-2, Low-1

Course Title	HEAT TRANSFER-LAB	Semester	VI
Course Code	MVJ20MEL67	CIE	50
Total No. of Contact Hours	20 L: T: P: 0:1: 3	SEE	50
No. of Contact Hours/week	02	Total	100
Credits	02	Exam. Duration	03

Course Learning Objectives:

- To impart knowledge on heat transfer through free and forced convection
- To provide a detailed experimental analysis for heat transfer through solids, fluids, and vacuum.
- To impart knowledge on convection, conduction, and radiation heat transfer in one and two dimensional steady and unsteady systems.

Sl. No	Experiments
	PART A
1	Emissivity measurement of radiating surfaces.
2	Heat transfer through forced convection.
3	Heat transfer through composite walls.
4	Heat transfer through pin fins.
5	Thermal conductivity of Metal Bar
6	Heat transfer by Natural (Free) Convection
	PART B
7	Determination of Stefan Boltzmann Constant.
8	Vapour compression Refrigerator
9	Parallel and Counter flow Heat Exchangers.
10	Boiling and Condensation Apparatus
	PART C (OPTIONAL)
11	Demonstration of Air Conditioner Trainer Kit.
12	Transient and Steady State heat transfer Analysis of plane slab and cylinder using numerical approach.

Course outcomes:	
CO1	Determine the emissivity of radiating surfaces
CO2	Determine heat transfer through forced and free convections.
CO3	Determination of Stefan boltzman constants.
CO4	Determine LMTD and effectiveness of parallel and counter flow heat exchangers.
CO5	Performance test of refrigerators and airconditioners.

Reference Books:	
1.	Heat transfer, a practical Approach, Yunus A. Cengel, Tata Mc Graw Hill Fifth edition.
Scheme of Examination: As per the MVJCE Autonomous Regulations, Semester End Examination (SEE) is to be conducted and evaluated for 100 marks which will be proportionately reduced and considered for 50 marks by the Grading authority.	
1.	One question is to be set from Part-A: 20 marks
2.	One question is to be set from Part-B: 20 Marks
3.	Viva – Voce: 10 marks

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	2	-	-	-	2	-	2	-	2
CO3	3	2	3	1	-	-	-	2	-	1	-	2
CO4	3	3	3	2	-	-	-	2	-	2	-	2
CO5	3	2	1	1	-	-	-	2	-	1	-	1

High-3, Medium-2, Low-1

Computer Aided Modelling and Analysis Lab

Test Facility in Heat Transfer Lab

Course Title	MINI PROJECT	Semester	VI
Course Code	MVJ20MEP68	CIE	50
Total No. of Contact Hours	-	SEE	50
No. of Contact Hours/week	-	Total	100
Credits	02	Exam. Duration	03 Hrs

Course Learning Objectives:

- To ensure graduates will be proficient in utilizing the fundamental knowledge of basic sciences, mathematics and Information Technology for the applications relevant to various streams of Engineering and Technology.
- To enrich graduates with the core competencies necessary for applying knowledge of computers and telecommunications equipment to store, retrieve, transmit, manipulate and analyze data in the context of business enterprise.
- To enable graduates to think logically, pursue lifelong learning and will have the capacity to understand technical issues related to computing systems and to design optimal solutions.
- To enable graduates to develop hardware and software systems by understanding the importance of social, business and environmental needs in the human context.
- To enable graduates to gain employment in organizations and establish themselves as professionals by applying their technical skills to solve real world problems and meet the diversified needs of industry, academia and research.

Course outcomes:

CO1	As a team, identify a real-world problem that can be solved using IT tools and techniques
CO2	Analyse existing artefacts and solutions and design novel effective approaches
CO3	To explore, select & deploy the appropriate tools for effective implementation of the design
CO4	To prepare the documentation for the design and implementation, write reports and make presentations justifying the choices made.
CO5	To develop the required collaboration and communication skills to work in a professional team and multi-disciplinary context.
CO6	To quickly develop Proof-of Concept of solutions to problems

Reference Books:

	IEEE papers, IEEE/ACM papers

Scheme of Examination:

1.	Project Report : 15 marks
2.	Project Model: 25 marks
3.	Viva – Voce: 10 marks

Course Title	MACHINE LEARNING	Semester	VI
Course Code	Audit Course – MVJ20MEAUD2	**CIE**	-
Total No. of Contact Hours	40 L: T:: P: 3: 0: 0	**SEE**	-
No. of Contact Hours/week	04	**Total**	-
Credits	-	**Exam. Duration**	-

Course objective is to:

- Obtain knowledge on well posed learning problems, perspectives and issues in machine learning.
- Obtain knowledge on concept learning tasks, artificial neural network and hypothesis testing.
- Ensure students develop competency in machine learning algorithms and apply for real time problems.

Module-1	RBT Level L1 L2	08Hrs.

Introduction:

Well posed learning problems, Designing a Learning system, Perspective and Issues in Machine Learning.

Concept Learning:

Concept learning task, Concept learning as search, Find-S algorithm, Version space, Candidate Elimination algorithm, Inductive Bias.

Laboratory / Experimental Sessions: Implement and demonstrate the FIND-S algorithm for finding the most specific hypothesis based on a given set of training data samples. Read the training data from a .CSV file.

Applications: To build analytical models, helping computers "learn" from data.

Video link / additional online information:

https://www.youtube.com/watch?v=GwIo3gDZCVQ

Module-2	RBT Level L2 L3 L4	08 Hrs.

Decision Tree Learning:

Decision tree representation, Appropriate problems for decision tree learning, Basic decision tree learning algorithm, hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning.

Laboratory / Experimental Sessions: Write a program to demonstrate the working of the decision tree based ID3 algorithm. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.

Applications: A decision tree is a support tool with a tree-like structure that models probable outcomes, cost of resources, utilities, and possible consequences.

Video link / additional online information:
https://www.youtube.com/watch?v=qDcl-FRnwSU

Module-3	RBT Level L1 L2 L3	08 Hrs.

Artificial Neural Networks:

Introduction to Artificial Neural Networks, Neural Network representation, Appropriate problems, Perceptrons, Back propagation algorithm.

Laboratory / Experimental Sessions: Build an Artificial Neural Network by implementing the Back propagation algorithm and test the same using appropriate data sets.

Applications: Machine translation, automation and data analytics.

Video link / additional online information:

https://www.youtube.com/watch?v=fv6Qll3laUU

Module-4	RBT Level L1 L2 L4	08 Hrs.

Bayesian Learning:

Introduction, Bayes theorem, Bayes theorem and concept learning, ML and LS error hypothesis, ML for predicting probabilities, MDL principle, Naive Bayes classifier, Bayesian belief networks, EM algorithm.

Laboratory / Experimental Sessions: Write a program to implement the naïve Bayesian classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.

Applications: Optimization of process parameters in digital manufacturing, product development.

Video link / additional online information:

https://www.youtube.com/watch?v=E3l26bTdtxI

Module-5	RBT Level L2 L3 L4	08 Hrs.

Evaluating Hypothesis:

Motivation, Estimating hypothesis accuracy, Basics of sampling theorem, General approach for deriving confidence intervals, Difference in error of two hypothesis, Comparing learning algorithms.

Instance Based Learning:

Introduction, k-nearest neighbour learning, locally weighted regression, radial basis function, cased-based reasoning.

Reinforcement Learning:

Introduction, Learning Task, Q Learning

Laboratory / Experimental Sessions: Implement the non-parametric Locally Weighted Regression algorithm in order to fit data points. Select appropriate data set for your experiment and draw graphs. **Applications:** Hypothesis testing, experimental validations and development of computation models. **Video link / additional online information:** https://www.youtube.com/watch?v=c8NcmNNfe-w

Course outcomes:	
CO1	Ability to apply the concepts of machine learning for solving real-time problems.
CO2	Identify the problems for machine learning and select either the supervised, unsupervised or reinforcement learning.
CO3	Ability to decide the appropriate algorithms for optimization of the process.
CO4	Ability to apply artificial neural network for optimizing the process parameters.
CO5	Select suitable testing procedures for evaluating the hypothesis and estimating the hypothesis accuracy.

Text Books:	
1.	Ethem Alpaydın, Introduction to machine learning, second edition, MIT press.
Reference Books:	
1.	Trevor Hastie, Robert Tibshirani, Jerome Friedman, h The Elements of Statistical Learning, 2nd edition, springer series in statistics.
2.	Tom M. Mitchell, Machine Learning, India Edition 2013, McGraw Hill Education.

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

High-3, Medium-2, Low-1