Scheme for VII 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	MVJ19ME71	Mechanical Vibrations	ME	3	2	0	3	50	50	100	4
2	PCC	MVJ19ME72	Operation Research	ME	3	2	0	3	50	50	100	4
3	PE	MVJ19ME73X	Professional Elective -4	ME	3	0	0	3	50	50	100	3
4	PE	MVJ19ME74X	Professional Elective -5	ME	3	0	0	3	50	50	100	3
5	OE	MVJ19ME75X	Open Elective – 2	ME	3	0	0	3	50	50	100	3
6	PCC	MVJ19MEL76	Design -Lab	ME	0	1	3	3	50	50	100	2
7	PCC	MVJ19MEL77	CIM-Lab	ME	0	1	3	3	50	50	100	2
8	Proj	MVJ19MEP78	Project Phase-1	ME				-	50	-	50	2
				Total	15	6	6	21	400	350	750	23

Note: 1. PCC: Professional Core Course , PE: Professional Elective, OE: Open Elective, Proj: Project Work
2. Students can take up Certification Course of 40 (30+10) hours duration on Data Analytics for 2 credits in the VII Semester to be offered in association with the Console Lancer LLP

Professional Elective -4:
1. MVJ19ME731: Renewable Energy Sources
2. MVJ19ME732: CAD/CAM,
3. MVJ19ME733: Computational Mechanics,
4. MVJ19ME734: Theory of Plasticity

Professional Elective -5:
1. MVJ19ME741: Solar Energy
2. MVJ19ME742: Lean Manufacturing,
3. MVJ19ME743: Control Engineering,
4. MVJ19ME744: Tribology

Open Elective – 2:
1. MVJ19ME751: Energy Engineering,
2. MVJ19ME752: Smart Materials and Mems,
3. MVJ19ME753: Operation Research

Course Title	MECHANICAL VIBRATIONS	Semester	7
Course Code	MVJ19ME71	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	4	Exam. Duration	3 Hrs

Course objective is to:

- Gain the knowledge of static and dynamic equilibrium conditions of mechanisms subjected forces and couple with and without friction.
- Understand vibrations characteristics of single degree of freedom systems.
- Characterise the single degree freedom systems subjected to free and forced vibrations with and without damping.

Module-1	RBT Level L1, L2, L3	10 Hrs.

Introduction: Definitions, Types of vibrations, Simple Harmonic Motion (SHM), Work done by harmonic force, Principle of super position applied to SHM, Beats, Fourier theorem, Numerical on Fourier theorem, Components of vibratory systems.

Laboratory Sessions/ Experimental learning:

- Study of Numerical models and analysis of Fourier theorems and beats using MATLAB.

Applications: Most of the machines, Musical instruments, etc.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=yddIT1GnIfE
2. https://www.youtube.com/watch?v=KKel19UfNno
3. https://www.youtube.com/playlist?list=PL46AAEDA6ABAFCA78
4. https://www.youtube.com/watch?v=9_d8CQrCYUw

Module-2	RBT Level L2, L3	10 Hrs.

Un damped free Vibrations (Single Degree of Freedom):

Methods of analysis – (Newton's, Energy & Rayleigh's methods). Derivations for spring mass systems, Natural frequencies of simple systems, Springs in series and parallel, Torsional and transverse vibrations, Effect of mass of spring and problems.

Laboratory Sessions/ Experimental learning:

- Study of Numerical models and analysis of vibratory systems using MATLAB.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=QIdIcCn6YGc
2. https://www.youtube.com/watch?v=4DF5qCxhxpM

3. https://www.youtube.com/watch?v=BkgzEdDlU78
4. https://www.youtube.com/watch?v=QIdIcCn6YGc

Module-3	RBT Level L1, L2, L3	10 Hrs.

Damped Free Vibrations: Introduction, Types of damping, and Vibrations with viscous damping, under damped, over-damped and critically-damped systems, logarithmic decrement.

Modal analysis and condition monitoring: Signal analysis, dynamic testing of machines and structures, Experimental modal analysis, Machine condition monitoring and diagnosis.

Laboratory Sessions/ Experimental learning:

- Study of Numerical models and analysis of Damped vibratory systems using MATLAB.

Applications: Bridges, Buildings, etc.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=YpiSZxDj7ws
2. https://www.youtube.com/watch?v=USa0VYAEzug
3. https://www.youtube.com/watch?v=YpiSZxDj7ws
4. https://www.youtube.com/watch?v=iNuV8Q0ZaPk

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

Forced Vibrations (Single Degree of Freedom):

Analysis of forced vibration with constant harmonic excitation, Magnification factor (M.F.), Vibration isolation - Transmissibility ratio, Excitation of support (absolute and relative), Numerical problems.

Vibration Measuring Instruments & Whirling Of Shafts: Vibrometer and accelerometer. Whirling of shafts with and without air damping, discussion of speeds above and below critical speeds.

Laboratory Sessions/ Experimental learning:

- Study of Two Degree Freedom systems like vehicle suspension and dynamic vibration absorber.

Video link / Additional online information:

1.https://www.youtube.com/watch?v=LbVL5O_bG9w
2. https://www.youtube.com/watch?v=4h5NOWTCVWM
3. https://www.youtube.com/watch?v=ETG6krVhN8w
4. https://nptel.ac.in/courses/112/103/112103111/

Module-5	RBT Level L3, L4, L5	10 Hrs.

Numerical Methods For Multi Degree Freedom Systems: Introduction, Influence coefficients, Maxwell reciprocal theorem, Dunkerley's equation. Orthogonality of principal modes, method of matrix iteration - Method of determination of all the natural frequencies using sweeping matrix and Orthogonality principle. Holzer's method, Stodola method.

Laboratory Sessions/ Experimental learning:

- Study of vibration analysis of real time application problems.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=TydULVPaFek
2. https://www.youtube.com/watch?v=M8bjJQFYMHU
3. https://nptel.ac.in/content/storage2/courses/112101096/download/lecture-29.pdf
4. https://www.youtube.com/watch?v=kT1c0iyFZmM

Course outcomes:

CO1	Understand types of vibration, SHM and methods of finding natural frequencies of simple mechanical systems.
CO2	Determine equation of motion, natural frequency, damping factor, logarithmic decrement of damped free vibration (SDOF) systems.
CO3	Determine the natural frequency, force and motion transmissibility of single degree freedom systems.
CO4	Determine equation of motion of rotating and reciprocating unbalance systems, magnification factor, and transmissibility of forced vibration (SDOF) systems.
CO5	Determine the equation of motion and degrees of freedom of multi-degree freedom system.

Text Books:

1.	**S.S. Rao, '*Mechanical Vibrations*',** Pearson Education Inc, 6th Edition, 2017. ISBN9780134361307.

Reference Books:

2.	**Leonanrd Meirovitch, '*Elements of Vibrations Analysis*',** TMH, Special Indian edition, 2007, ISBN-81-7700-047-0.
3.	**S.Graham Kelly, '*Mechanical Vibrations*',** Schaum's outline series, TMH, Special Indian Edition, 2007, ISBN-14-09780070616790.

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

High-3, Medium-2, Low-1

Course Title	OPERATIONS RESEARCH	Semester	VII
Course Code	MVJ19ME72	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:

- To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
- To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and Machinery.

Module-1	RBT Level L1, L2, L3	10Hrs.

Introduction:

Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

Laboratory Sessions/ Experimental learning: Case Studies for formulation of LLP to know the statistics for daily marketing of newspaper, banking sector, different firms.

Applications: Formulation can be used in agriculture, financial sector, marketing.

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

http://nptel.ac.in/courses/111107128/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-2	RBT Level L2, L4	10Hrs.

Linear Programming Problems:

Simplex method, Canonical and Standard form of LPP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

Laboratory Sessions/ Experimental learning: Case Studies for formulation of LLP to utilize minimum resources available to achieve the target for different sectors like supply chain management, marketing.

Applications: LPP can be used in defense, industries sectors and hospitals.

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

http://nptel.ac.in/courses/112106134/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-3	RBT Level L2, L3, L4	10Hrs.

Transportation Problem:

Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.

Assignment Problem:

Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems

Laboratory Sessions/ Experimental learning: Case Studies for different transportation system to obtain best optimal distance to reach the target.

Applications: These methods can be used in transportation of goods and any other services.

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

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

Module-4	RBT Level L1, L2, L4	10Hrs.

Network analysis:

Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Numerical Problems.

Queuing Theory:

Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.

Laboratory Sessions/ Experimental learning: Building a different network activity for financial and marketing projects management.

Applications: Network and Queuing methods can be adopted in completing various projects within the given deadline to earn the profit and minimize the loss.

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

http://nptel.ac.in/courses/110106062/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-5	RBT Level L2, L3,L5	10Hrs.

Game Theory:

Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2xN and Mx2 games by graphical method. Formulation of games.

Sequencing:

Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of 2 jobs on 'm' machines using graphical method.

Laboratory Sessions/ Experimental learning: Collecting the statistical data to develop the project using Game theory and Sequencing.

Applications: These methods give the perfect results of any production of machines.

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

http://nptel.ac.in/courses/112106131/

https://nptel.ac.in/courses/112/106/112106134/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

Course Outcomes:	
CO1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.
CO2	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.
CO3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.

CO4	Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks. Solve waiting line problems for M/M/1 and M/M/K queuing models.
CO5	Solve problems on game theory for pure and mixed strategy under competitive environment. Determine minimum processing times for sequencing for different n jobs and m machines using Johnson's algorithm.

Text Books:	
1	Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt. Ltd. 2016.
2	Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD. Publications, New Delhi – 2007.
Reference Books	
1	Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006
2	Operations Research, Paneerselvan, PHI

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

High-3, Medium-2, Low-1

Course Title	RENEWABLE ENERGY SOURCES	Semester	7
Course Code	MVJ19ME731	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:

- Students will be able to understand various types and utilization of Non-conventional Energy Sources.
- Students will gain the knowledge about the utilisation and applications of solar energy.
- Students will be able to explain how solar radiation will be converted into Thermal Energy and working of Photovoltaic Cells.
- Students will understand how the Biomass (Natural Waste) is converted in useful energy and Geothermal Energy.
- Students will gain the knowledge about the generation of power from Wind Energy, Ocean Thermal Energy Conversion and Tidal Energy.

Module-1	RBT Level L1, L2&L4	8Hrs.

Introduction: Energy sources, India's production, and reserves of commercial energy sources, need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Waterpower, wind biomass, ocean temperature difference, tidal and waves, geothermal, tar sands and oil shale, nuclear (Brief descriptions); advantages and disadvantages, comparison (Qualitative and Quantitative).

Laboratory Sessions/ Experimental learning: Case Study on Different Energy Sources.

Applications: Energy Sector

NPTEL Link: https://nptel.ac.in/courses/121/106/121106014/

Video link: https://www.youtube.com/watch?v=e0nkkKDjY50&t=2s

https://www.youtube.com/watch?v=e0nkkKDjY50&t=2s

https://www.youtube.com/watch?v=EXcNXLv2W3A

Module-2	RBT Level L1,L2&L3	8Hrs.

Solar Radiation: Extra-Terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam, diffuse and global radiation, solar radiation data.

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle expression for the angle between the incident

beam and the normal to a plane surface (No derivation) local apparent time. Apparent motion of sum, day length, numerical examples. Radiation Flux on a Tilted Surface. Solar radiation measurement devices.

Laboratory Sessions/ Experimental learning: Analysis of solar radiation data in different places across the country.

Applications: Solar Power Generation.

NPTEL Link: https://nptel.ac.in/courses/121/106/121106014/

Video link: https://www.youtube.com/watch?v=CRFpoZjeWa4

https://www.youtube.com/watch?v=E4S02rc9AvM

https://www.youtube.com/watch?v=ur5muGY5Gy4

Module-3	RBT Level L1,L2 &L3	8Hrs.

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid) (Quantitative analysis); sensible heat storage, latent heat storage, application of solar energy water heating. Space heating and cooling, active and passive systems, power generation, refrigeration. Distillation (Qualitative analysis) solar pond, principle of working, operational problems.

Photovoltaic Conversion: Description, principle of working and characteristics, applications. Study of solar power stations in India. Limitations of solar power.

Laboratory Sessions/ Experimental learning: Case study for design of solar panel for domestic applications & Case study on solar charging station.

Applications: Solar power stations.

NPTEL Link: https://nptel.ac.in/courses/121/106/121106014/

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

https://www.youtube.com/watch?v=GzMuLpsRY-8

Module-4	RBT Level L1,L2&L3	8Hrs.

Energy from Biomass: Photosynthesis, photosynthetic oxygen production, energy plantation, biogas production from organic wastes by anaerobic fermentation, description of bio-gas plants, transportation of bio-gas, problems involved with bio-gas production, application of bio-gas, application of bio-gas in engines, advantages.

Geothermal Energy Conversion: Principle of working, types of geothermal station, geothermal plants in the world, scope of geothermal energy and challenges associated with geothermal energy conversion.

Laboratory Sessions/ Experimental learning: Visit to Biomass Gas Production Plant. Case study on design of bio-gas plant for 1Mw.

Applications: Production of Gas and Power Generation.

NPTEL Link: https://nptel.ac.in/courses/121/106/121106014/ Video link: https://www.youtube.com/watch?v=sJQwJX-YysY https://www.youtube.com/watch?v=JInatzTBiKA https://www.youtube.com/watch?v=adSkrlyd2rQ&t=1s		
Module-5	RBT Level L1,L2&L3	8Hrs.
Wind Energy: Properties of wind, availability of wind energy in India, wind velocity and power from wind; major problems associated with wind power, wind machines; Types of wind machines and their characteristics, horizontal and vertical axis windmills, elementary design principles; coefficient of performance of a windmill rotor, aerodynamic considerations of windmill design, numerical examples. **Tidal Power**: Tides and waves as energy suppliers and their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, limitations. **Ocean Thermal Energy Conversion (OTEC)**: Principle of working, Rankine cycle, OTEC power stations in the world, limitations of OTEC. **Laboratory Sessions/ Experimental learning**: Assignments on making models of windmills. **Applications**: Power Generation and Low heat Applications. **NPTEL Link**: https://nptel.ac.in/courses/121/106/121106014/ **Video link**: https://www.youtube.com/watch?v=-f88zBS8jlg&t=2s, https://www.youtube.com/watch?v=WZBiznycjns https://www.youtube.com/watch?v=F2YsrxpQPwE		

Course outcomes:	
CO1	Understand various types and utilization of Non-conventional Energy Sources.
CO2	To understand the impact of solar collector geometry.
CO3	Apply the knowledge of solar radiation for power generation and domestic applications.
CO4	Understand the Biomass (Natural Waste) conversion to useful energy and principles of geothermal Energy.
CO5	Gain the knowledge about the generation of power from Wind Energy, Ocean Thermal Energy Conversion and Tidal Energy.

Text Books:	
1.	Non-Conventional Energy Sources by G.D Rai K, Khanna Publishers, 2003
2.	Solar energy, by Subhas P Sukhatme – Tata McGraw Hill, 2nd Edition, 1996

3.	Renewable Energy Sources and Conversion Technology by N.K.Bansal, Manfred Kleeman & Mechael Meliss, Tata McGraw Hill, 2001.
Reference Books:	
1	Renewable Energy Resources, John W.Twidell Anthony D. Weir El, BG 2001.
2	Solar Power Engineering, P.K.Nag, Tata McGraw Hill, 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	2	1	-	-	-	2	3	-	-	-	-	2
CO2	2	1	-	-	-	2	3	-	-	-	-	2
CO3	2	1	-	-	-	2	3	-	-	-	-	2
CO4	2	1	-	-	-	2	3	-	-	-	-	2
CO5	2	1	-	-	-	2	3	-	-	-	-	2

High-3, Medium-2, Low-1

Course Title	CAD/CAM	Semester	VII
Course Code	MVJ19ME732	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 know the fundamentals of Computer Aided Design (CAD)
- Information regarding various CAD hardware
- Programming concepts in Computer Numerical Control (CNC)
- To impart knowledge of computer aided quality control and shop floor control
- Robotics and their applications

Module-1	RBT Level: L1, L2	8 Hrs

Introduction: Role of computers in design and manufacturing. Influence of computers in manufacturing environment. Product cycle in conventional and computerized manufacturing environment. Introduction to CAD, Introduction to CAM. Advantages and disadvantages of CAD and CAM.

Hardware in CAD: Basic Hardware structure, working principles, usage and types of hardware for CAD - input and output Devices, memory, CPU, hardcopy and Storage devices.

Laboratory Sessions/ Experimental learning: Allowing customization and reconfiguration of manufacturing processes with minimal downtime and cost. Providing management with detailed and timely information about the manufacturing process

Applications: Computer aided designing. Computer aided manufacturing

Video link / Additional online information :

https://youtu.be/EgKc9L7cbKc

https://www.youtube.com/embed/1y2Vec5XdXg

https://www.youtube.com/embed/HJLuKbU11jY

https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod02lec07.mp4

Module-2	RBT Level: L2, L3	8 Hrs

Computer Graphics: Software configuration of a graphic system, function of a Graphics package, construction of geometry, wire frame and solid modelling, CAD/CAM integration. Describe modelling facilities. Introduction to exchange of modelling data – Basic features of IGES, STEP, DXF and DMIS.

Laboratory Sessions/ Experimental learning: A model designed can be carried in a storage device along many others.Strengthens companies' ability to respond quickly to customers' demands Applications: **Video link / Additional online information** : https://youtu.be/JuNDS4R-OwI https://youtu.be/iWxS2zpaRjk. https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod02lec08.mp4 https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod02lec09.mp4		
Module-3	**RBT Level** : L2, L3	8 Hrs
CNC Tooling: Turning tools geometry, milling tooling systems, tool pre-setting, ATC work holding. CAM PROGRAMMING: Overview of different CNC machining centers, CNC turning centers, high speed machine tools, MCE. **CNC Programming**: Part program fundamentals – steps involved in development of a part program. Manual part programming, milling, turning center programming. Laboratory Sessions/ Experimental learning: CNC Tooling, CNC programming and operations Applications: **Video link / Additional online information** : https://www.youtube.com/watch?v=pPwyYFvRLts https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod06lec31.mp4 https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod06lec32.mp4 https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod06lec33.mp4		
Module-4	**RBT Level** : L1, L2	8 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, **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**: Integration of automated assignment and reporting of factory floor operations through machine and material handling equipment sensors and software **Applications**: Reduces Total Cost of Ownership. Improves quality and consistency of inputs **Video link / Additional online information** : https://www.youtube.com/watch?v=20_K7c65Swg		

http://www.youtube.com/watch?v=g-zMhN4S8yY

https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod08lec43.mp4

https://nptel.ac.in/content/storage/112/104/112104188/MP4/mod08lec44.mp4

Module-5	RBT Level: L2, L3	8 Hrs

Introduction to Robotics: Introduction, Robot Configuration, Robot Motions, Programming the Robots, Robot- Programming Languages, End effectors, Work Cell, Control and Interlock, Robot Sensor, Robot Applications.

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: Robot programming and handling

Applications: Industry 4.0, Internet of Things (IOT) in different manufacturing industry

Video link / Additional online information :

https://www.youtube.com/watch?v=DaWMvEY3Qgc

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

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

https://nptel.ac.in/content/storage2/112/104/112104289/MP4/mod12lec50.mp4

Course outcomes:

CO1	Understand the concepts of CAD and the required hardware
CO2	Understand CAM and CNC machines
CO3	Program CNC machines
CO4	Explain the use of different computer applications in Shop Floor Control & computer aided quality control
CO5	Understand and program the robot.

Text Books:

1.	CAD / CAM Principles and Applications by P N Rao, 3rd Edition, 2015, Tata McGraw-Hill.
2.	Automation, Production Systems and Computer-Integrated Manufacturing, by Mikell P Groover, 4th Edition,2015, Pearson Learning.
3	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	COMPUTATIONAL MECHANICS	Semester	VII
Course Code	MVJ19ME733	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

Course objective is to:

- Understand and systematize numerical solution techniques for the partial differential equations governing the physics of mechanical engineering problems.
- Understand the mathematical models used to describe behaviour and results of most numerical methods used in engineering mechanics.
- Writing codes using MATLAB, C, C++ etc to solve problems pertaining to engineering mechanics.

Module-1	RBT Level L1,L2,L3	8 Hrs.

Introduction, Conservation Laws and Model Equations, Conservation Laws, Euler Equations, Navier-Stokes Equations, Linear Convection and Diffusion Equation, Linear Hyperbolic Systems, Differential Form and Solution in Wave Space

Laboratory Sessions/ Experimental learning: Simulation of flow through a simple Convergent/Divergent Nozzle

Video link:

1. https://www.youtube.com/watch?v=vgFoleINnqU
2. https://www.youtube.com/watch?v=f856f2r3Btk
3. https://nptel.ac.in/courses/112/103/112103296/
4. https://www.youtube.com/watch?v=9uHOkjV68EY

Module-2	RBT Level L1,L2,L3	8 Hrs.

Finite-Difference Approximations, Space Derivative Approximations Finite-Difference Operators Constructing Differencing Schemes of Any Order, Fourier Error Analysis, Difference Operators at Boundaries.

The Semi-Discrete Approach, Reduction of PDE's to ODE's, Real Space and Eigen space.

Laboratory Sessions/ Experimental learning: Writing codes to solve ODE/PDE using MATLAB software.

Video link:

1. https://www.youtube.com/watch?v=g3Xw1r7QGOE
2. https://www.youtube.com/watch?v=f67jpwJu-d0

3. https://www.youtube.com/watch?v=UWqVvR8SmDA
4. https://www.youtube.com/watch?v=K5aYW0QUg7c

Module-3	RBT Level L1,L2,L3	8 Hrs.

Finite-Volume Methods, Model Equations in Integral Form, Multidimensional Examples

Finite-Element Methods, Approximation of Elliptic Problems, Piecewise Polynomial Approximation, A Posterior Error Analysis, Evolution Problems.

Laboratory Sessions/ Experimental learning: Write MATLAB codes to solve simple bar and beam problems using FEM methods

Video link:

1. https://nptel.ac.in/courses/112/103/112103295/
2. https://www.youtube.com/watch?v=o2Vlt1avXCs
3. https://www.youtube.com/watch?v=Jqa-aFE9-GI
4. https://www.youtube.com/watch?v=PBjGdQOghJE

Module-4	RBT Level L1,L2.L4	8 Hrs.

Time-Marching Methods for ODE's

Converting Time-Marching Methods to ODE's, The λ-σ Relation, Accuracy Measures of Time-Marching Methods, Linear Multistep Methods, Predictor-Corrector Methods, Implementation of Implicit Methods

Stability of Linear Systems, Dependence on the Eigen system, Inherent Stability of ODE's, Numerical Stability of ODE's, Time-Space Stability and Convergence of ODE's, Numerical Stability Concepts in the Complex σ-Plane, Numerical Stability Concepts in the Complex λh-Plane, Fourier Stability Analysis, Consistency.

Laboratory Sessions/ Experimental learning: Solving 1D linear wave equation by using Time-marching method of finite difference method.

Video link:

1.https://ocw.mit.edu/courses/chemical-engineering/10-34-numerical-methods-applied-to-chemical-engineering-fall-2015/class-videos/session-22-partial-differential-equations-1/

2. https://nptel.ac.in/courses/101/104/101104062/

3. https://www.youtube.com/watch?v=p0V1eSlM2xo

4. https://www.youtube.com/watch?v=ly4S0oi3Yz8

Module-5	RBT Level L3,L4,L5	8 Hrs.

Selecting a Time-Marching Method, Stiffness Definition for ODE's and Relation of Stiffness to Space Mesh Size, Practical Considerations for Comparing Methods, Comparing the efficiency of Explicit Methods, Coping with Stiffness

Relaxation Methods, Classical Relaxation, The ODE Approach to Classical Relaxation, Eigen systems of the Classical Methods, Nonstationary Processes

Laboratory Sessions/ Experimental learning: Eigenvalue problems and Mechanical Vibrations using MATLAB code.

Video link:

1. https://ocw.mit.edu/courses/chemical-engineering/10-34-numerical-methods-applied-to-chemical-engineering-fall-2015/class-videos/session-22-partial-differential-equations-1/
2. https://www.youtube.com/watch?v=OET0qwat15o
3. https://www.youtube.com/watch?v=NjoMoH51UZc
4. https://www.youtube.com/watch?v=TDc6J2R9h3Q

Course outcomes:	
CO1	Students will be able to develop mathematical models of physical phenomena.
CO2	Students will be able to solve ordinary and partial differential equations analytically as well as numerically.
CO3	Students will learn fundamentals and applications of algebra for engineering problems
CO4	Students will learn fundamentals of statistics and probability and its applications for engineering mechanics.
CO5	Students will be able to apply the concepts of engineering mechanics for real time engineering problems.

Text Books:	
1.	Advanced Engineering Mathematics, 9th edition, by Erwin Kreyszig JOHN WILEY & SONS, INC.
2.	Advanced Engineering Mathematics, 2nd edition, by M D Greenberg, Pearson Education
3.	Numerical Methods for Engineers by Stephen C Chapra, and Raymond C Canale McGraw-Hill
Reference Books:	
1.	Computational Continuum Mechanics 3rd edition by Ahmed A Shabana, Wiley publications.

2.	Continuum Mechanics using Mathematica by Antonio Romano, Renato Lancellotta and Addolorata Marasco.
3.	Mathematical Modeling in Continuum Mechanics, 2nd edition, by Roger Temam and Alain Miranville, Cambridge University 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	3	2	1	2	-	-	-	-	2	1	1	1
CO2	3	2	1	2	-	-	-	-	2	1	1	1
CO3	3	2	2	3	-	-	-	-	2	1	2	1
CO4	3	2	1	2	-	-	-	-	2	1	2	1
CO5	2	2	2	2	1	-	-	-	2	2	1	1

High-3, Medium-2, Low-1

Course Title	THEORY OF PLASTICITY	Semester	VII
Course Code	MVJ19ME734	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3:0:0	SEE	50
No. of Contact Hours/week	03	Total	100
Credits	03	Exam. Duration	03 Hours

Course objective is to:

- Introduce the concepts of Plasticity and mechanism of plastic deformation in metals.
- Expose the students to elasto-plastic problems involving plastic deformation of beams and bars.
- Introduce the concepts of slip line field theory.

Module-1	RBT Level L1,L2,L3	8 Hrs.

Brief review of fundamentals of elasticity: Concept of stress, stress invariants, principal Stresses, octahedral normal and shear stresses, spherical and deviatoric stress, stress transformation.

Concept of strain: engineering and natural strains, octahedral strain, deviator and spherical strain tensors, strain rate and strain rate tensor, Cubical dilation, generalized Hooke's law, Numerical problems.

Laboratory Sessions/ Experimental learning: Analyzing the different mechanical properties of materials using computerized universal testing machine in order to know the material behavior in elastic region.

Applications: Plasticity in Structural Engineering

Video links: https://nptel.ac.in/courses/112105123/

Module-2	RBT Level L1,L2,L3	8 Hrs.

Plastic Deformation of Metals: Crystalline structure in metals, mechanism of plastic deformation, factors affecting plastic deformation, strain hardening, recovery, recrystallization and grain growth,

Yield Criteria: Introduction, yield or plasticity conditions, Von Mises and Tresca criterion, geometrical representation, yield surface, yield locus (two dimensional stress space), experimental evidence for yield criteria, problems

Laboratory Sessions/ Experimental learning: Analyzing the different mechanical properties of materials using computerized universal testing machine in order to know the material behavior in plastic region.

Applications: Plastic deformation of structural materials.

Video links: https://nptel.ac.in/courses/112105123/4

Module-3	RBT Level L1,L2,L3	8 Hrs.
Stress Strain Relations: Idealised stress-strain diagrams for different material models, empirical equations, Levy-Von Mises equation, Prandtl-Reuss and Saint Venant theory, experimental verification of Saint Venant's theory of plastic flow. Concept of plastic potential, maximum work hypothesis, mechanical work for deforming a plastic substance **Laboratory Sessions/ Experimental learning**: **Applications**: Theoretical evaluation of the deformation of a plastic **Video links**: https://nptel.ac.in/courses/112105123/6		
Module-4	**RBT Level L1,L2,L4**	**8 Hrs.**
Bending of Beams: Stages of plastic yielding, analysis of stresses, linear and nonlinear stress strain curve, problems. **Torsion of Bars**: Introduction, plastic torsion of a circular bar, elastic perfectly plastic material, elastic work hardening of material, problems. **Laboratory Sessions/ Experimental learning**: Conduct of 2 point bending test and 3 point bending tests. **Applications**: Yielding of bridges under bending loads. **Video links**: https://nptel.ac.in/courses/112105123/6		
Module-5	**RBT Level L3,L4,L5**	**8 Hrs.**
Slip Line Field Theory: Introduction, basic equations for incompressible two dimensional flows, continuity equations, stresses in conditions of plain strain, convention for slip lines, geometry of slip line field, properties of the slip lines, construction of slip line nets. **Laboratory Sessions/ Experimental learning**: Demonstration of the geometry of slip line field in materials to students. **Applications**: Slip line field for stresses in conditions of plain strain. **Video links**: https://www.youtube.com/watch?v=gObbNJ6g1xQ		

Course outcomes:	
CO1	Understand stress, strain, deformations, relation between stress and strain and plastic deformation in solids.
CO2	Understand plastic stress-strain relations and associated flow rules.
CO3	Perform stress analysis in beams and bars including Material nonlinearity.
CO4	Analyze the yielding of a material according to different yield theory for a given state of stress.
CO5	Interpret the importance of plastic deformation of metals in engineering problems

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

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	SOLAR ENERGY	Semester	VII
Course Code	MVJ19ME741	CIE	50
Total No. of Contact Hours	40 L : T : P :: 3: 0 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3 Hrs

Course objective is to:

- To learn the various available forms of energy.
- To understand the various methods of harnessing non-conventional energy.
- To study the various applications of solar energy and their economic analysis.
- To learn the fundamental concepts about solar energy systems and devices

Module-1	RBT LEVEL L1, L2	8 Hrs.

Introduction: Energy source, renewable energy sources, renewable energy potential and achievements in India, Sustainable energy: The engine of sustainable development Solar energy: General characteristics of solar energy; the Sun, solar spectrum, spectral solar impedance.

Solar Radiation at the Earth Surface: Solar constant beam, diffuse and global radiation. Solar radiation data of India. Measurement of solar radiation: Pyrometer, pyro-heliometer, sunshine recorder.

Solar radiation geometry: Sun earth angles- latitude, declination, hour angle, zenith, solar altitude angle, surface azimuth angle, solar azimuth angle, Local apparent time, solar time, apparent motion of sun, day length, numerical examples. Flux on a plane surface, Solar radiation on a inclined surface- Beam, defuse, reflected radiation on a tilted surface, expression for flux on a tilted surface, monthly average hourly and daily radiation on inclined surface. Numerical examples.

Laboratory Sessions/ Experiential learning:

- Design of solar panels for street lights in campus
- Build a solar cell sun tracker to track the sun with calibrated panels.

Applications: Solar energy is used for producing heat, electricity.

Video link: https://nptel.ac.in/courses/103/103/103103206/
https://www.youtube.com/watch?v=ucBP1cADTgI
https://www.youtube.com/watch?v=gKSUTAC1lh0
https://nptel.ac.in/courses/115/103/115103123/

Module-2	RBT LEVEL L1, L2	8 Hrs.

Solar thermal radiation devices: Liquid flat plate collectors, solar air heaters, concentrating collectors like cylindrical, parabolic, evacuated tubular collectors. Storage devices: Sensible heat storage, latent heat storage. Application of solar energy: water heating, space heating, space

cooling, active and passive cooling systems. Various power generation methods; Solar furnace, Refrigeration, Distillation, Solar ponds; theory, working principle, operational problems.

Solar photovoltaic system: Introduction, Description, Principles of working of solar cell: Doping, Fermi level, p-n junction, photovoltaic effect. Photovoltaic Material:- Single crystal solar cell, Poly crystal solar cell, thin film solar cell, I-V characteristic, limits to cell efficiency, Cell temperature factors affecting PV cell performance Current status and Future potential of P.V. cells.

Laboratory Sessions/ Experiential learning:

- Schematic of solar pump

Applications: Solar cells are used for heating.

Video link: https://nptel.ac.in/courses/112/105/112105050/

https://www.youtube.com/watch?v=rg1x4jJmSl4

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

https://www.youtube.com/watch?v=ZLgOoMSlS3Y

Module-3	RBT LEVEL L1, L2	8 Hrs.

Performance analysis of liquid flat plate collectors: General description, collector geometry, selective surface, basic energy balance equation, stagnation temperature, transmissivity of the cover system, transmissivity- absorptivity product, numerical examples. The overall loss coefficient, correlation for the top loss coefficient, bottom and side loss- coefficient, problems.

Temperature distribution Solar Concentrators: Temperature distribution between the collector tubes, collector heat removal factor, collector efficiency factor and collector flow factor, mean plate temperature, instantaneous efficiency. Effect of various parameters on the collector performance: Collector orientation, selective surface, fluid inlet temperature, number of covers, dust. Solar Concentrators: Introduction, characteristic parameters: Aperture area, Acceptance angle, absorber area, geometric concentration ratio. Local concentration ratio or brightness concentration ratio, intercept factor, optical efficiency, thermal efficiency. Concentration ratio.

Laboratory Sessions/ Experiential learning:

- Studying the performance of Temperature distribution Solar Concentrators.

Applications: Solar collectors will collect the solar radiations.

Video link: https://nptel.ac.in/courses/103/103/103103206/

https://www.youtube.com/watch?v=wvl0QAQCJyc

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

https://www.youtube.com/watch?v=JbJ7AVHBQfs

https://www.youtube.com/watch?v=EjjZJH_7Di0

Module-4	RBT LEVEL L1, L2, L3	8 Hrs.

Concentrators: Concentration, Non-tracking concentrator. Geometrical optics in concentrators: Ray tracing in a reflecting surface, ray tracing in a refracting surface. Theoretical solar image. Thermal analysis: Cylindrical parabolic concentrator, Hemispherical Bowl Mirror, V- trough. Tracking Methods: Three Dimensional Concentrators, Two dimensional concentrators. Materials for concentrators: - Reflecting and Refracting surfaces, receiver cover and surface coating, working fluids, insulation, Numerical problems

Laboratory Sessions/ Experiential learning:

- Making the model of cylindrical parabolic concentrator, Hemispherical Bowl Mirror.

Applications: Solar Concentrators will improve the efficiency of the solar system.

Video link: https://nptel.ac.in/courses/103/103/103103206/

https://www.youtube.com/watch?v=hVik_I2ONUU

https://www.youtube.com/watch?v=-rYmTp5BW8c

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

Module-5	RBT LEVEL L1, L2, L3	8 Hrs.

Solar power stations in India: Elements of a solar power station, design of solar power system, solar power charging stations, design of solar panels for lighting purposes. Etc., Solar powered house. Repair of solar panels. Wind -Solar hybrid power plant. Installation, commissioning of grid solar power plant, Maintenance of solar power plants, safety considerations of solar power plants.

Laboratory Sessions/ Experiential learning:

- Studying the Repair of Solar panels.

Applications: Solar cells are used for lighting of street lights.

Video link: https://nptel.ac.in/courses/103/103/103103206/

https://www.youtube.com/watch?v=8m0IAy8jjLY

https://nptel.ac.in/courses/115/103/115103123/

https://www.youtube.com/watch?v=r6OnREoqoOM

Course outcomes:

CO1	Gain an understanding of the available solar energy and the current solar energy conversion and utilization processes.
CO2	Illustrate the working principle of solar radiation measuring devices.
CO3	Analyse the effect of various parameters on the performance of liquid flat plate collectors
CO4	Analyse the effect of various parameters on the performance concentrators.
CO5	Understand the manufacturing processes involved, environmental challenges that need to be solved, economic aspects, and future potentials of solar energy utilization.

Text Books:	
1.	Solar Energy: Fundamentals, Design, Modelling and Applications by G.N. Tiwari, Narosa Publishing House, 2002 ISBN 81-7319-450-5.
2.	Solar Engineering of Thermal Processes by Duffie, J.A. and Beckman, W.A., John Wiley and Sons, New York (1991).
Reference Books:	
1.	Solar Energy-Principles of Thermal Collection and Storage by S.P. Sukhatme, Tata McGraw-Hill publishing company limited, New Delhi, ISBN 0-07-462453-9.

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)
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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
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CO2	3	2	2	1	2	-	1	-	-	-	-	-
CO3	3	1	1	-	2	-	-	-	-	-	-	-
CO4	3	1	1	3	3	-	2	-	-	-	-	-
CO5	2	1	3	3	1	2	2	-	-	-	-	1

High-3, Medium-2, Low-1

Course Title	LEAN MANUFACTURING	Semester	7
Course Code	MVJ19ME742	CIE	50
Total No. of Contact Hours	40 L: T : P :: 3: 0 : 0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	3	Exam. Duration	3

Course objective is to:

- Course aims at providing knowledge about various aspects of Lean Manufacturing.
- Identify how a production line can be run efficiently.
- Reflect upon the critical skills and evaluate their own performance.
- Relate concepts such as 'Just in Time manufacturing' and 'Lean manufacturing to the context of an assembly line.
- Applying concepts of 5S and Six sigma concepts in industries.

Module-1	RBT Level L1,L2, & L3	8 Hrs.

Introduction: Conventional Manufacturing versus Lean Manufacturing – Principles of Lean Manufacturing – Basic elements of lean manufacturing – Introduction to LM Tools,

Toyota Production System: Just in time production system. JIT Logic -Pull system Japanese approach to production elimination of waste - JIT implementation requirements JIT application for job shops, Case studies.

Laboratory Sessions/ Experimental learning:

- Operational availability equals machine run time/machine use time.
- To implement the system, three wastes must be removed from the production system: Design out overburden (muri) Reduce inconsistency (mura) Eliminate waste (muda).

Applications:

- Front line production team creates a daily discipline of seeking improvement through collaboration and focusing on the daily process.
- Toyota's own continuous improvement journey.

Video link / Additional online information:

- Lean manufacturing techniques, IIT Roorkee https://www.youtube.com/watch?v=G_0bl6FHo_c
- Lean manufacturing and Kanban Design and planning. Module 37, Prof. Shantanu Bhattacharya, IIT Kanpur. Video Lecture--https://nptel.ac.in/courses/112/104/112104188/
- Toyota Production system- forklift https://www.toyotaforklift.com/resource-library/material-handling-solutions/products/valuing-the-toyota-production-system-and-lean-manufacturing
- Coursera

https://www.coursera.org/courses?query=lean%20manufacturing

- Coursera

https://www.coursera.org/lecture/fixing-healthcare-delivery-advanced-lean/what-are-the-fundamental-principles-of-lean-tps-TG2wY

Module-2	RBT Level L1,L2&L3	8 Hrs.

Adaptable Kanban System: Kanban rules, supplier Kanban and sequence schedule used by supplier, Monthly information & daily information.

Kaizen: Introduction, Elements of Kaizen, Kaizen – The Three Pillars

Mass production: The rise & fall of Mass Production, Mass production, work force, organization, tools, product –logical limits of Mass production.

Laboratory Sessions/ Experimental learning:

- Introduce Kanban board apps which can be called on for projects big and small, individual and team efforts, one-time or ongoing work.
- Introduce Kaizen into daily activities.

Applications:

- Kanban being applied in traditional project management contexts such as construction and engineering projects.
- Kaizen is must in Toyota- Automotive manufacturer

Video link / Additional online information:

- Kanban Approach, Prof Rajat Agarwal IIT Roorkee
  https://www.youtube.com/watch?v=Zjx7zCjLjyw
- Lean Manufacturing: The Path to Success with Paul Akers
  https://www.youtube.com/watch?v=oarLDeAFSj4
  https://www.youtube.com/watch?v=UMFNys3Yavo
- Coursera
  https://www.coursera.org/courses?query=kanban
- Coursera
  https://www.coursera.org/lecture/six-sigma-principles/jit-kanban-qlp9X

Module-3	RBT Level L1,L2&L3	8 Hrs.

Reduction of setup times- The Quick-Change over- Concepts and Techniques: Setup Concepts, practical procedures for reducing setup time, Pareto diagram.

Standardization of operations: Elements: Takt time, Work Sequence, Standard inventory, Machine layout, multi-function workers and job rotation. Improvement activities to reduce work force and increase worker morale -foundation for improvements.

Laboratory Sessions/ Experimental learning:

- Implement the quick-change over in industry shopfloor for improving productivity.

Applications:

- In make to stock situations, manufacturers usually opt to produce large quantities or lot sizes in order to minimize setup costs.
- *Standardization* can be applied to any process, any task or procedure that is relevant to the organization: answering the phone, doing payroll, taking down client information, keeping track of tasks/process.

Video link / Additional online information:

- Reduction of setup times and Standardization of operations https://www.creativesafetysupply.com/articles/kanban/
- Single Minute Exchange of Dies (SMED) which is a Lean manufacturing tool to reduce the Change-over time of the machines. https://www.youtube.com/watch?v=9ANXiDt7z6c&t=1s
- Coursera https://www.coursera.org/lecture/theimprovephaseforthesixsigmablackbelt/setup-reduction-6-10-mBSym
- Coursera https://www.coursera.org/lecture/themeasurephaseforthesixsigmablackbelt/lean-terminology-9-22-pAxYI

Module-4	RBT Level L1,L2&L4	8 Hrs.

House of Lean -5S's and Waste Walks, Visual Management, Value Stream Mapping-Understanding the current state and designing the future state.

Managing lean enterprise - Finance, Career ladders, geographic spread and advantages of global enterprise.

Laboratory Sessions/ Experimental learning:

- Apply 5S's in automobile manufacturing industries.
- Apply 5S's in food products production industries.

Applications:

- **5S's** is a highly systematic method (or set of techniques) of organizing and optimizing any warehouse, office, institution (i.e. university, hospital, library etc) or a factory's housekeeping.

Video link / Additional online information:

- Lean Agile mindset and the House of Lean https://www.youtube.com/watch?v=FM8cxTHA3lI
- A Spotlight on Leaders: Re-Thinking the Retail Food Industry https://www.lean.org/Events/WebinarHome.cfm
- Coursera https://www.coursera.org/lecture/lean-manufacturing-services/introduction-to-lean-5jjrs

- Coursera
  https://www.coursera.org/lecture/fundamentals-of-management/1-4-lean-7Serp

Module-5	RBT Level L1,L2&L3	8 Hrs.

Six sigma concepts: History, definitions, Statistical definitions, quality levels, Technical aspects, Six sigma for all: benefits to organizations, customers, suppliers and employers, Design for Six Sigma, DMAIC principles, DMADV principles, merits and demerits.

Brief discussion on following topics: Artificial intelligence (AI) with lean manufacturing, Digital manufacturing, Re-Thinking Production Flow (Lean Technique).

Laboratory Sessions/ Experimental learning:

- Apply six sigma concepts in production industries.
- Introduce artificial intelligence (AI) to increase productivity.

Applications:

- Production industries for taking help of artificial intelligence (AI)

Video link / Additional online information:

- Six sigma -NPTEL Prof. Vinod Gupta, School of management, IIT Kharagpur. https://nptel.ac.in/courses/110/105/110105039/
- From Lean Production to the Lean Enterprise https://hbr.org/1994/03/from-lean-production-to-the-lean-enterprise
- Coursera https://www.coursera.org/lecture/six-sigma-principles/six-sigma-methodology-zykLE
- Coursera https://www.coursera.org/learn/introduction-to-ai

Course outcomes:

CO1	To understand issues & challenges in implementing & developing lean manufacturing techniques from TPS & its contribution for improving organizational performance
CO2	Apply lean techniques like Kanban rules, Kaizen to bring competitive business culture for improving organization performance
CO3	Applying reduction of setup times and Standardization of operations analyze how lean techniques can be applied to manufacturing & service industry
CO4	Implementing 5S's and global enterprise to present industries
CO5	Analyzing six sigma and artificial intelligence in supporting production

Text Books:

1.	Productions and Operations Management - ChaselAquilino - Dreamtechlatestedition.

2.	Toyoto Production System -An integrated approach to Just in Time - Yasuhiro Monden - Engineering and Management Press -Institute of Industrial Engineers Norcross Georgia - 1983.
3.	Lean Thinking - James P. Womack and Daniel T. Jones- Simon & Schuster, Inc, 2003.
Reference Books:	
1.	Japanese Manufacturing Techniques. The Nine Hidden Lessons by simplicity - Richard Schourberger - ASQC Press1991.
2.	Quality Function Development - James Bossert - ASQC Press1991
3.	Lean and Six Sigma - Six Sigma Black Belt (2007 BOK): Enterprise-Wide Deployment Paper Back by Suvabrata Mitra.

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

High-3, Medium-2, Low-1

Course Title	CONTROL ENGINEERING	Semester	7
Course Code	MVJ19ME743	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

Course objective is to:

- Mathematical modelling of the mechanical systems using differential equations
- Deduction of Transfer functions using block Diagrams and signal flow graphs
- Emphasize on transient characteristics and response of the systems and Routh - Hurwitz stability criteria
- Analysis of frequency response characteristics of control systems.
- Construction of root locus plots and to ascertain the stability of the control systems

Module-1	RBT Level L1,L2&L3	8 Hrs.

Introduction: Concept of automatic controls, Open loop and closed loop systems, Concepts of feedback, requirements of an ideal control system, Types of controllers-Proportional, Integral, Differential, Proportional & Integral, Proportional Differential and Proportional Integral Differential controllers.

Laboratory Sessions/ Experimental learning:

1. Basics and heated tank: PID standard temperature control of heated tank, No control heated tank

Applications:

2. Traffic light control system
3. Fan with controller

Video link / Additional online information:

1. https://nptel.ac.in/courses/108/106/108106098/
2. https://nptel.ac.in/courses/108/102/108102043/
3. https://nptel.ac.in/courses/108/101/108101037/
4. https://nptel.ac.in/courses/108/106/108106098/

Module-2	RBT Level L1,L2&L3	8 Hrs.

Block diagram Algebra: General representation of a feedback control system, transfer functions, rules of block diagram algebra, reduction of block dia. to obtain closed loop transfer function. Signal flow graphs: Mason's gain formula

Laboratory Sessions/ Experimental learning:

1. Feed forward liquid level control in double tank.

Applications:

2. Liquid level control

Video link / Additional online information:

1. https://nptel.ac.in/courses/108/106/108106098/
2. https://nptel.ac.in/courses/108/102/108102043/
3. https://nptel.ac.in/courses/108/101/108101037/
4. https://nptel.ac.in/courses/108/106/108106098/

Module-3	RBT Level L1,L2&L4	8 Hrs.

Steady State Response and Transient Response: Transient response and steady state analysis of unit, step input, steady state characteristics, equilibrium in a system Routh's stability criterion for a control system.

Root Locus Plots: Root locus method: Significance of Root locus, angle and magnitude conditions, breakaway points, angles of departure and arrival, construction of Root locus using general rules and steps, Lead and Lag compensation.

Laboratory Sessions/ Experimental learning:

- Step test, Set point weighing

Applications:

- Speed control of DC motor

Video link / Additional online information:

1. https://nptel.ac.in/courses/108/106/108106098/
2. https://nptel.ac.in/courses/108/102/108102043/
3. https://nptel.ac.in/courses/108/101/108101037/
4. https://nptel.ac.in/courses/108/106/108106098/

Module-4	RBT Level L1,L2&L3	8 Hrs.

Frequency Domain Analysis: Relationship between time and frequency response, Polar plot, Bode's Plot, Nyquist plot and Nyquist stability criterion, Relative Stability, Phase and Gain Margins.

Laboratory Sessions/ Experimental learning:

- . PD control for desired pole placement

Applications:

- Magnetic levitation

Video link / Additional online information:

1. https://nptel.ac.in/courses/108/106/108106098/
2. https://nptel.ac.in/courses/108/102/108102043/
3. https://nptel.ac.in/courses/108/101/108101037/
4. https://nptel.ac.in/courses/108/106/108106098/

Module-5	RBT Level L1,L2&L3	8 Hrs.

Module - 5 System Compensation and State Variable Characteristics of Linear Systems: Series and feedback compensation, Introduction to state concepts, state equation of linear continuous data system.

Laboratory Sessions/ Experimental learning:

1. Develop motors speed controls as required in industries.

Applications:

2. To analyse the control action on the liquid levels in tanks.

Video link / Additional online information:

1. https://nptel.ac.in/courses/108/106/108106098/
2. https://nptel.ac.in/courses/108/102/108102043/
3. https://nptel.ac.in/courses/108/101/108101037/
4. https://nptel.ac.in/courses/108/106/108106098/

Course outcomes:

CO1	Mathematical modeling of the mechanical systems using differential equations
CO2	Deduction of Transfer functions using block Diagrams and signal flow graphs
CO3	Emphasize on transient characteristics and response of the systems and Routh - Hurwitz stability criteria
CO4	Analysis of frequency response characteristics of control systems.
CO5	Construction of root locus plots and to ascertain the stability of the control systems

Text Books:

1.	"Modern Control Engineering" by K Ogata.
2.	"Automatic Control Systems" by B C Kuo.

Reference Books:

1.	"Modern Control Systems" by R C Dorf and R H Bishop
2.	"Control Systems Engineering" by N S Nise.
3.	"Discrete-time Control Systems" by K Ogata.

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- Quizzes/mini tests (4 marks)
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CO-PO Mapping												
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
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CO3	3	3	2	1	1	1	2	1	1	1	1	2
CO4	3	3	3	2	1	1	2	1	1	1	1	3
CO5	3	3	3	2	1	1	2	1	1	1	1	3

High-3, Medium-2, Low-1

Course Title	TRIBOLOGY	Semester	VII
Course Code	MVJ19ME744	CIE	50
Total No. of Contact Hours	40 L : T : P :: 3:0:0	SEE	50
No. of Contact Hours/week	4	Total	100
Credits	03	Exam. Duration	3hrs

Course objective is to:

- Describe the Lubrication principle and mechanisms.
- Finding the load carrying capacity in light and heavy loaded journal bearings.
- Friction force and power loss Analysis in hydrodynamic and hydrostatic lubrication.
- Identify the appropriate material for bearings based on the application.
- Study the different wear mechanism in tribological components.

Module-1	RBT Level: L1, L2	8 Hrs.

Introduction to Tribology:
Properties of oils and equation of flow: Viscosity, Newton's Law of viscosity, Hagen-Poiseuille Law, Flow between parallel stationary planes, viscosity measuring apparatus. Lubrication principles, classification of lubricants.

Laboratory Sessions/ Experimental learning: Finding out the viscosity of different liquids (oils).

Applications: It can be used in bearings, brakes, seals and cams.

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

https://nptel.ac.in/courses/112102014/

https://www.nptel.ac.in/courses/112102015/

http://www.nptelvideos.in/2012/12/tribology.html

Module-2	RBT Level: L2, L3	8 Hrs.

Hydrodynamic Lubrication:
Friction forces and power loss in lightly loaded bearing, Petroff's law, Tower's experiments, idealized full journal bearings.

Mechanism of Pressure Development in an Oil Film:
Reynold's investigations, Reynold's equation in two dimensions, Partial journal bearings, end leakages in journal bearing, Numerical problems.

Laboratory Sessions/ Experimental learning: Finding the Friction loss and power loss in journal bearings

Applications: These concepts are used for lubrication purpose for automobile vehicles.

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

https://www.nptel.ac.in/courses/112102015/

https://nptel.ac.in/courses/112/102/112102014/

Module-3	RBT Level : L2, L3	8 Hrs.

Slider / Pad Bearing with a Fixed and Pivoted Shoe:

Pressure distribution, Load carrying capacity, coefficient of friction, frictional resistance in a pivoted shoe bearing, influence of end leakage, numerical examples.

Laboratory Sessions/ Experimental learning: Study of load carrying capacity in bearings.

Applications: These concepts are used for lubrication purpose for automobile vehicles.

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

http://www.nptelvideos.in/2012/12/tribology.html

https://www.youtube.com/watch?v=hNfgnX2lA18

Module-4	RBT Level : L2, L3,L4	8 Hrs.

Hydrostatic Lubrication:

Introduction to hydrostatic lubrication, hydrostatic step bearings, load carrying capacity and oil flow through the hydrostatic step bearing.

Bearing Materials:

Commonly used bearings materials, properties of typical bearing materials.

Laboratory Sessions/ Experimental learning: Selection of proper of bearing materials according to applications.

Applications: Applied for Nano materials, composite materials.

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

https://nptel.ac.in/courses/112102014/

https://www.youtube.com/watch?v=HTIzwP8BKC8

Module-5	RBT Level: L2, L4,L5	8 Hrs.

Wear: Introduction, Types of Wear Mechanism: Adhesive Wear- Quantitative Equations- Experimental Evidence- Role of Metallurgical Compatibility-Structural Effects-Grain Boundary Effects, Abrasive Wear(by Plastic Deformation and Fracture)-Abrasive Wear by Plastic Deformation-Quantitative Equation-Effect of Relative Hardness of Abrasive Medium to Workpiece , Fatigue Wear-Rolling Contact.

Fatigue-Static Fatigue, Impact Wear-Solid Particle Erosion- Quantitative Equations- Cavitation Erosion- Percussion, Chemical (Corrosive) Wear- Tribochemical Wear, Fretting and Fretting Corrosion.

Laboratory Sessions/ Experimental learning: Study of Abrasive Wear (by Plastic Deformation and Fracture) and safety measurements

Applications: Applies for wear and tear of different materials, fatigue strength.

Video link / Additional online information (related to module if any):
http://www.nptelvideos.in/2012/12/tribology.html https://ocw.mit.edu/courses/mechanical-engineering/2-800-tribology-fall-2004/lecture-notes/

Course outcomes:	
CO1	Realize and describe the Lubrication principle and mechanisms.
CO2	Compute load carrying capacity in light and heavy loaded journal bearings.
CO3	Analyse the friction force and power loss in hydrodynamic and hydrostatic lubrication.
CO4	Identify the appropriate material for bearings based on the application.
CO5	Recognize the different wear mechanism in tribological components

Text Books:	
1.	Lubrication of Bearings – Theoretical Principles and Design by Redzimovskay E I., Oxford press company 2000
2.	Principles and Applications of Tribology by Moore, Pergamaon press 1998
Reference Books:	
1	Fundamentals of Tribology by Basu S K., Sengupta A N., Ahuja B. B., , PHI 2006 .
2	Introduction to Tribology Bearings by Mujumdar B. C., S. Chand company pvt. Ltd 2008

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

High-3, Medium-2, Low-1

Course Title	ENERGY ENGINEERING	Semester	VII
Course Code	MVJ19ME751	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 Hours

Course objective is to:

- Understand energy scenario, energy sources and their utilization
- Learn about energy conversion methods
- Study the principles of renewable energy conversion systems

Module-1	RBT LEVEL L1, L2	08 Hrs

Steam Generators: Coal and ash handling, Generation of steam using forced circulation, high and supercritical pressures, LaMount, Benson, Velox, Loeffer, Schmidt steam generators, Cooling towers and Ponds, Accessories such as Superheaters, De-superheater, Economizers, Air preheaters.

Geothermal Energy Conversion: Principle of working, types of geothermal station with schematic diagram, geothermal plants in the world, problems associated with geothermal conversion, scope of geothermal energy.

Laboratory Sessions/ Experiential learning:

- Making the model of La Mount, Benson, Velvox, Loeffer steam generators.

Applications: Electricity can be produced from Steam and Geothermal energy.

Video link: https://nptel.ac.in/courses/112/107/112107291/
https://www.youtube.com/watch?v=ZTKCSjIAZyo
https://www.youtube.com/watch?v=txoEqwSxUrQ
https://www.youtube.com/watch?v=mCRDf7QxjDk

Module-2	RBT LEVEL L1, L2, L3	08 Hrs

Solar Radiation: Extra-terrestrial radiation, spectral distribution of extra-terrestrial radiation, solar constant, solar radiation at the earth's surface, beam and global radiation, solar radiation data

Solar Radiation Measurement: Pyranometer, shading ring, Pyrheliometer, sunshine recorder, schematic diagrams and principles of working. (no numericals)

Solar Radiation Geometry: Flux on a plane surface, latitude, declination angle, surface azimuth angle, hour angle, zenith angle, solar altitude angle, expression for the angle between the incident beam and the normal to a plane surface (No derivation) local apparent motion of sun, day length and numerical examples

Solar Thermal Conversion: Collection and storage, thermal collection devices, liquid flat plate collectors, solar air heaters concentrating collectors (cylindrical, parabolic, paraboloid), sensible heat storage, latent heat storage, application of solar energy water heating. Solar heating and cooling, active and passive systems, power generation, refrigeration. Distillation, solar pond, principle of working, operational problems, Solar cells and its applications

Laboratory Sessions/ Experiential learning:

- Studying of Solar collectors.

Applications: Solar cells are used for heating the water.

Video link: https://nptel.ac.in/courses/103/103/103103206/
https://nptel.ac.in/courses/112/105/112105050/
https://www.youtube.com/watch?v=ucBP1cADTgI
https://www.youtube.com/watch?v=rg1x4jJmSl4

Module-3	RBT LEVEL L1, L2, L3	08 Hrs

Tidal Energy: Tidal power, Site selection, Single basin and double basin systems, Advantages and disadvantages of tidal energy.

Wind Energy: Wind energy-Advantages and limitations, wind velocity and wind power, Basic components of wind energy conversion systems, horizontal and vertical axis wind mills, coefficient of performance of a wind mill rotor, Applications of wind energy.

Biomass Energy: Photosynthesis, photosynthetic oxygen production, energy plantation. Bio Chemical Route: Biogas production from organic wastes by anaerobic fermentation, Bio gas plants-KVIC, Janta, Deenbhandu models, factors affecting bio gas generation. Thermal gasification of biomass, updraft and downdraft gasifiers.

Laboratory Sessions/ Experiential learning:

- Making the model of Tidal energy, Wind energy and Biomass energy plant.

Applications: Electricity can be produced from Tidal energy, Wind energy and Biomass energy.

Video link: https://nptel.ac.in/courses/103/103/103103206/
https://www.youtube.com/watch?v=qSWm_nprfqE
https://www.youtube.com/watch?v=m7ImT4CdcPo
https://www.youtube.com/watch?v=7AlxnCIyHG4

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

Hydroelectric plants: Advantages & disadvantages of water power, Hydrographs and flow duration curves, numericals, Storage and pondage, General layout of hydel power plants-components such as Penstock, surge tanks, spill way and draft tube and their applications, pumped storage plants, Detailed classification of hydroelectric plants, water hammer.

Ocean Thermal Energy: Ocean thermal energy conversion, Principle and working of Rankine cycle, Problems associated with OTEC.

Laboratory Sessions/ Experiential learning:

- Making the model of Hydroelectric and Ocean Power plant.

Applications: Electricity can be produced from Hydroelectric and Ocean Thermal energy.

Video link: https://nptel.ac.in/courses/112/107/112107291/
https://www.youtube.com/watch?v=OC8Lbyeyh-E
https://www.youtube.com/watch?v=_c9tBOjny28
https://www.youtube.com/watch?v=IASV8IH-ytE

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

Nuclear Energy Principles of release of nuclear energy-Fusion and fission reactions. Nuclear fuels used in the reactors, Chain reaction, Moderation, breeding, Multiplication and thermal utilization factors. General components of a nuclear reactor and materials,

Hydrogen Energy: properties of Hydrogen with respect to its utilization as a renewable form of energy sources, production of hydrogen, electrolysis of water, thermal decomposition of water, thermos chemical production and bio-chemical production.

Laboratory Sessions/ Experiential learning:

- Making Model of Nuclear power plant

Applications: Nuclear power plants are used for producing the Electricity.

Video link: https://nptel.ac.in/courses/112/101/112101007/
https://youtu.be/_BbUOAjGpzw
https://www.youtube.com/watch?v=_UwexvaCMWA&t=86s
https://www.youtube.com/watch?v=a4pXAmljdUA

Course outcomes:

CO1	Understand the construction and working of steam generators and their accessories and Discuss characteristics of geothermal energy
CO2	Analyse solar energy with the help of solar radiation measuring instruments and Explain the angles related to solar radiation geometry and design solar collectors for harnessing solar energy.
CO3	Explain different types of wind mills and their design principles. Compute coefficient of performance of wind mill. Discuss characteristics of tidal energy, Bio mass energy.
CO4	Discuss characteristics of Hydro electric plants, ocean thermal energy
CO5	Discuss characteristics of Nuclear energy and Describe the methods of production of hydrogen for utilization as a renewable form of source of energy.

Text Books:	
1.	**Power Plant Engineering by P. K. Nag** Tata McGraw Hill Education Private Limited, New Delhi, Third Edition, 2012
2.	**Power Plant Engineering Arora and Domkundwar ,Dhanpat Rai & Co**. (P) Ltd. Sixth Edition, 2012.
3.	**Non-conventional Sources of Energy, G.D. Rai, Khanna** Publishers, New Delhi, Fifth Edition, 2015
Reference Books:	
1.	**Non-conventional energy resources, B H Khan**, McGraw Hill Education 3rd Edition
2.	**Principles of Energy conversion,A. W. Culp Jr** McGraw Hill 1996
3.	**Power Plant Technology M.M. EL-Wakil** McGraw Hill International 1994
4.	**Subhas P.Sukhatme, J K Nayak, "Solar energy",** Tata Mc Graw Hill,India 3rd Edition. 2009, ISBN: 9780070142961
5.	**John W.Twidell, Tony Weir, "Renewable energy resources" , Routledge**, 4th edition, 2014, ISBN:9780415633581

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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	2	1	1	1	1	2	1	-	-	-	-	-
CO2	3	3	2	-	-	-	1	-	-	-	-	2
CO3	3	1	-	-	-	-	1	-	-	3	-	2
CO4	3	1	-	-	-	-	1	-	-	3	-	2
CO5	-	-	-	-	-	-	2	-	-	3	-	2

High-3, Medium-2, Low-1

Course Title	SMART MATERIALS AND MEMS	Semester	VII
Course Code	MVJ19ME752	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:

- This course provides a detailed overview to smart materials, piezoelectric materials structures and its characteristics.
- The study of Smart structures and Modelling helps in Vibration control using smart materials in various applications. Helps to understand the principles and concepts of using MEMS, ER& MR Fluids for various applications.

Module-1	RBT Level L1,L2	08 Hrs.

Introduction: Closed loop and Open loop Smart Structures. Applications of Smart structures, Piezoelectric properties. Inchworm Linear motor, Shape memory alloys, Shape memory effect-Application, 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:

- Fabrication Inchworm motors, Different shape memory alloys materials test in different temperature.

Applications: Dental Implants,

Video link / Additional online information:

https://www.youtube.com/watch?v=YJ0WWW0AoUk

Module-2	RBT Level L1,L2	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, Twisted and Braided Fibre Optic sensors, Optical fibres as load bearing elements, Crack detection applications, Integration of Fibre optic sensors and shape memory elements. –

Laboratory Sessions/ Experimental learning:

- ER and MR fluid test and Optical fiber testing.

Applications: Communication industry.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=KK_h3-BucR0
2. https://www.youtube.com/watch?v=VS5xy9-av1c
3. https://www.youtube.com/watch?v=-ap00IUJm7k&list=PLFW6lRTa1g83YaqmM9r2MAAiJVY93bOP7

Module-3	RBT Level L1,L2	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, Mollusks. Biomimetic sensing, Challenges and opportunities.

Laboratory Sessions/ Experimental learning:

- Parallel damping test, Vibration analysis using gyroscope. Identification of biomimetic structure in our surroundings.

Applications: Civil Construction industry.

Video link / Additional online information:

1. https://www.youtube.com/watch?v=WopxFu1jwpM
2. https://www.youtube.com/watch?v=AEWqAcSeQm4

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

MEMS: History of MEMS, Intrinsic Characteristics, Devices: Sensors and Actuators. Micro fabrication: 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, Magnetization and Nomenclatures, Fabrication and case studies, Comparison of major sensing and actuation methods

Laboratory Sessions/ Experimental learning:

- Different models to be created using piezoelectric materials.

Applications: All type of Sensors manufacturing industry,

Video link / Additional online information:

https://www.youtube.com/watch?v=j9y0gfN9WMg&list=PLWzzOF0m-O4isgM-VSVm-73wyLHaB49bB

Module-5	RBT Level L2,L3	08 Hrs.

Polymer MEM S& Microfluidics: Introduction, Polymers in MEMS (Polyimide, SU-8, LCP, PDMS, PMMA, Parylene, Others) Applications (Acceleration, Pressure, Flow, Tactile sensors). Motivation for micro fluidics, Biological Concepts, Design and Fabrication of Selective components. Channels and Valves.

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:

- Different Sensors Assembly or fabrication.

Applications: Automotive industry, Robotics, Health care industry.

Video link / Additional online information:

https://www.youtube.com/watch?v=nE1C4ghfvac&list=PLgMDNELGJ1CbufZjqWa8uoSlQWKqVwPN7

Course outcomes:	
CO1	Describe the methods of controlling vibration using smart systems and fabrication methods of MEMS.
CO2	Explain the principle concepts of Smart materials, structures, Fibre optics, ER & MR Fluids, Biomimetics and MEMS with principles of working.
CO3	Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication.
CO4	Summarize the methods and uses of Micro fabrications, Biomimetics, types of polymers used in MEMS, Fibre optics, piezoelectric sensing and actuation.

Text Books:	
1.	A.V.Srinivasan, "*Smart Structures –Analysis and Design*", Cambridge University Press, New York, 2001, (ISBN: 0521650267).
2.	M.V.Gandhi and B.S.Thompson, "*Smart Materials and Structures*", Chapmen & Hall, London, 1992 (ISBN:0412370107)
Reference Books:	
1.	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	1	2	1	-	-	-	1	1	-	2
CO2	3	3	1	2	2	-	-	-	1	1	-	2
CO3	3	3	1	2	3	-	-	-	1	1	-	2
CO4	3	3	1	2	3	-	-	-	1	1	-	2

High-3, Medium-2, Low-1

Course Title	OPERATIONS RESEARCH	Semester	VII
Course Code	MVJ19ME753	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:

- To enable the students to understand the scientific methods of providing various departments of an organization with a quantitative basis of decision making.
- To enable the students to understand the importance of various tools and techniques in finding optimal solutions to problems involving limited resources in the form of Men, Materials and Machinery.

Module-1	RBT Level L1, L2, L3	8 Hrs.

Introduction:

Evolution of OR, Definitions of OR, Scope of OR, Applications of OR, Phases in OR study. Characteristics and limitations of OR, models used in OR, Linear Programming Problem (LPP), Generalized LPP- Formulation of problems as L.P.P. Solutions to LPP by graphical method (Two Variables).

Laboratory Sessions/ Experimental learning: Case Studies for formulation of LLP to know the statistics for daily marketing of newspaper, banking sector, different firms.

Applications: Formulation can be used in agriculture, financial sector, marketing.

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

http://nptel.ac.in/courses/111107128/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-2	RBT Level L2, L4	8 Hrs.

Linear Programming Problems:

Simplex method, Canonical and Standard form of LPP problem, slack, surplus and artificial variables, Solutions to LPP by Simplex method, Big-M Method and Two Phase Simplex Method, Degeneracy in LPP. Concept of Duality, writing Dual of given LPP. Solutions to L.P.P by Dual Simplex Method.

Laboratory Sessions/ Experimental learning: Case Studies for formulation of LLP to utilize minimum resources available to achieve the target for different sectors like supply chain management, marketing.

Applications: LPP can be used in defense, industries sectors and hospitals.

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

http://nptel.ac.in/courses/112106134/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-3	RBT Level L2, L3, L4	8 Hrs.

Transportation Problem:

Formulation of transportation problem, types, initial basic feasible solution using North-West Corner rule, Vogel's Approximation method. Optimality in Transportation problem by Modified Distribution (MODI) method. Unbalanced T.P. Maximization T.P. Degeneracy in transportation problems, application of transportation problem.

Assignment Problem:

Formulation, Solutions to assignment problems by Hungarian method, Special cases in assignment problems, unbalanced, Maximization assignment problems. Travelling Salesman Problem (TSP). Difference between assignment and T.S.P, Finding best route by Little's method. Numerical Problems

Laboratory Sessions/ Experimental learning: Case Studies for different transportation system to obtain best optimal distance to reach the target.

Applications: These methods can be used in transportation of goods and any other services.

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

http://nptel.ac.in/courses/111107128/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-4	RBT Level L1, L2, L4	8 Hrs.

Network analysis:

Introduction, Construction of networks, Fulkerson's rule for numbering the nodes, AON and AOA diagrams; Critical path method to find the expected completion time of a project, determination of floats in networks, PERT networks, determining the probability of completing a project, predicting the completion time of project; Cost analysis in networks. Numerical Problems.

Queuing Theory:

Queuing systems and their characteristics, Pure-birth and Pure-death models (only equations), Kendall & Lee's notation of Queuing, empirical queuing models – Numerical on M/M/1 and M/M/C Queuing models.

Laboratory Sessions/ Experimental learning: Building a different network activity for financial and marketing projects management.

Applications: Network and Queuing methods can be adopted in completing various projects within the given deadline to earn the profit and minimize the loss.

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

http://nptel.ac.in/courses/110106062/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

https://onlinecourses.nptel.ac.in/noc21_mg43/preview

Module-5	RBT Level L2, L3,L5	08 Hrs.

Game Theory:

Definition, Pure Strategy problems, Saddle point, Max-Min and Min-Max criteria, Principle of Dominance, Solution of games with Saddle point. Mixed Strategy problems. Solution of 2X2 games by Arithmetic method, Solution of 2xN and Mx2 games by graphical method. Formulation of games.

Sequencing:

Basic assumptions, Johnson's algorithm, sequencing 'n' jobs on single machine using priority rules, sequencing using Johnson's rule-'n' jobs on 2 machines, 'n' jobs on 3 machines, 'n' jobs on 'm' machines. Sequencing of 2 jobs on 'm' machines using graphical method.

Laboratory Sessions/ Experimental learning: Collecting the statistical data to develop the project using Game theory and Sequencing.

Applications: These methods give the perfect results of any production of machines.

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

http://nptel.ac.in/courses/112106131/

https://nptel.ac.in/courses/112/106/112106134/

https://nptel.ac.in/courses/111/107/111107128/

https://nptel.ac.in/courses/110/104/110104063/

Course Outcomes:	
CO1	Understand the meaning, definitions, scope, need, phases and techniques of operations research.
CO2	Formulate as L.P.P and derive optimal solutions to linear programming problems by graphical method, Simplex method, Big-M method and Dual Simplex method.

CO3	Formulate as Transportation and Assignment problems and derive optimum solutions for transportation, Assignment and travelling salesman problems.
CO4	Construct network diagrams and determine critical path, floats for deterministic and PERT networks including crashing of Networks. Solve waiting line problems for M/M/1 and M/M/K queuing models.
CO5	Solve problems on game theory for pure and mixed strategy under competitive environment. Determine minimum processing times for sequencing for different n jobs and m machines using Johnson's algorithm.

Text Books:	
1.	Operations Research, Theory and Applications, Sixth Edition, J K Sharma, Trinity Press, Laxmi Publications Pvt. Ltd. 2016.
2.	Operations Research, P K Gupta and D S Hira, S. Chand and Company LTD. Publications, New Delhi – 2007.
Reference Books:	
1	Operations Research, An Introduction, Seventh Edition, Hamdy A. Taha, PHI Private Limited, 2006
2	Operations Research, Paneerselvan, PHI

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

High-3, Medium-2, Low-1

Course Title	DESIGN LAB	Semester	7
Course Code	MVJ19MEL76	CIE	50
Total No. of Contact Hours	20 L: T: P: 0: 1: 3	SEE	50
No. of Contact Hours/week	03	Total	100
Credits	02	Exam. Duration	03

Course Learning Objectives:

- To understand the concepts of natural frequency, logarithmic decrement, damping and damping ratio.
- To understand the techniques of balancing of rotating masses.
- To verify the concept of the critical speed of a rotating shaft.
- To illustrate the concept of stress concentration using Photo elasticity.
- To appreciate the equilibrium speed, sensitiveness, power and effort of a Governor.
- To illustrate the principles of pressure development in an oil film of a hydrodynamic journal bearing.

Sl. No	Experiments
	PART A
1	Experimental studies of Single Degree of Freedom Vibrating systems.
2	Experiment on Governors – Porter/Proell/Hartnell to find the equilibrium speed, sensitiveness, power and effort.
3	Experiment on the balancing of rotating masses.
4	Experiment on rotating shafts to find the critical speed.
5	Demonstration of writing of codes in MATLAB/PYTHON to find the natural frequency, logarithmic decrement, damping ratio and damping coefficient in a single degree of freedom vibrating systems.
	PART B
6	Experiment on Photo-elastic materials for the determination of the fringe constant using. a) Circular disc subjected to diametral compression. b) Pure bending specimen.
7	Determination of stress concentration using Photo-elasticity for simple components like plate with a hole under tension or bending, circular disk with circular hole under compression, 2D Crane hook
8	Experiment on Journal bearing to find the pressure distribution.
9	Determination of Principal Stresses and strains in a member subjected to combined loading using Strain

10	Determination of stresses in Curved beam using strain gauge.
11	Static structural analysis of a curved beam in ANSYS Workbench to determine the deformation, stresses and strains. (Von mises/Principal Stresses/Strains and total deformation)
Course outcomes:	
CO1	Determine the natural frequency of the free and forced vibration of single degree freedom systems, critical speed of shafts.
CO2	Carry out balancing of rotating masses.
CO3	Characterize the performance of governors.
CO4	Determine stresses in disk, beams, plates and hook using photo elastic bench.
CO5	Determination of Pressure distribution in Journal bearing
CO6	Analyse the stress and strains using strain gauges and write the programs.

Reference Books:	
1.	Shigley's Mechanical Engineering Design, Richard G. Budynas, and J.Keith Nisbett, McGraw-Hill Education, 10th edition, 2015.
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	1	1	1	2	1	1	1	1
CO2	3	3	3	1	1	1	1	2	1	1	2	2
CO3	3	3	3	1	1	1	1	2	1	1	2	2
CO4	3	3	3	1	1	2	2	2	2	2	2	2
CO5	2	3	3	2	1	1	1	2	1	1	2	2

High-3, Medium-2, Low-1

Course Title	CIM LAB	Semester	7
Course Code	MVJ19MEL77	CIE	50
Total No. of Contact Hours	20 L: T: P: 0: 1: 3	SEE	50
No. of Contact Hours/week	03	Total	100
Credits	02	Exam. Duration	03

Course Learning Objectives:

- To introduce students to the concepts of computer integrated manufacturing.
- To expose students to CNC part programming.
- To make the students understand the importance of automation in industries.
- To expose students to FMS, Robotics, and Hydraulics and Pneumatics.
- To introduce students to modelling and design for manufacturing using Autodesk Fusion 360.

Sl. No	Experiments
	PART A
1	Introduction to G Codes, M Codes and CNC Turning and Milling Machines.
2	CNC manual Part programming for turning operations.
3	Simulation of Turning operations using CAM Software.
4	Demonstration of turning operations using CNC part programs on MTAB NC Turn Machine.
	PART B
5	CNC manual Part programming for milling operations.
6	Simulation of Milling operations using CAM Software packages
7	Demonstration of Milling operations using CNC part programs on MTAB NC Mill Machine.
8	Robot Programming – Pick and Place and Stacking programming – Demonstration.
	PART C (OPTIONAL)
9	Modelling and Design for Mechanical Engineers using the modelling software available.
10	Basic Study of Pneumatics, Hydraulics and Electro pneumatics.

Course outcomes:

CO1	Write the CNC Programs for turning and milling.
CO2	Carry out machining of the components using CNC programs.
CO3	Program the robots for simple operations.
CO4	Carryout the post processing of CNC programs on control systems.
CO5	Carryout the modelling and design for new age manufacturing systems.

Reference Books:	
1.	Mikell P Groover, Automation, Production Systems and Computer-Integrated Manufacturing, Pearson Learning, 4th edition, 2015.
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	3	3	1	1	1	2	1	1	1	1	3
CO2	3	3	2	1	1	1	2	1	1	1	1	2
CO3	3	3	2	1	1	1	2	1	1	1	1	2
CO4	3	3	3	2	1	1	2	1	1	1	1	3
CO5	3	3	3	2	1	1	2	1	1	1	1	3

High-3, Medium-2, Low-1

Photoelastic apparatus in Design Lab for Experimental Stress Analysis

MTAB XLTURN – Turning Centre and XLMILL – Milling Centre in CIM Lab

Course Title	PROJECT PHASE-1	Semester	VII
Course Code	MVJ19MEP78	CIE	50
Total No. of Contact Hours	-	SEE	-
No. of Contact Hours/week	-	Total	50
Credits	02	Exam. Duration	-

Course Learning Objectives:

- To facilitate the students learn and apply an engineering design process in mechanical engineering, including project resource management.
- To test their learned theory knowledge in an actual working situation.
- To provide an opportunity to the students to apply what they have learned throughout the course of graduate program by undertaking a specific problem

Sl. No	PHASES FOR PROJECT WORK
1	Introduction to the project area.
2	Extensive literature survey.
3	List of proposed objectives.
4	Proposed Methodology.
5	Time estimation for completing the project.
Course outcomes:	
CO1	Literature gap determination and definition of the problem.
CO2	Evaluate the various validation and verification methods.
CO3	Scientific Design / Numerical Analysis / Analytical model and interpret them.
CO4	Apply tools / techniques for problem solving and prepare project work.

Reference Books:	
1.	C. R. Kothari, "*Research Methodology: Methods and Techniques*", New Age International (P) Limited, Second Edition, 2004.
2.	Ranjit Kumar, "*Research Methodology: A step-by step guide for beginners*", SAGE Publications Ltd, Third Edition, 2011
Scheme of Examination:	
1.	Introduction and Problem Definition: 10 marks
2.	Literature survey: 10 marks
3.	Project objectives and methodology: 10 marks
4.	Presentation: 10 marks
5.	Viva – Voce: 10 marks

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

High-3, Medium-2, Low-1

Course Title	BIG DATA ANALYTICS	Semester	VII
Course Code	CERTIFICATE COURSE	CIE	--
Total No. of Contact Hours	30	SEE	--
No. of Contact Hours/week	03	Total	--
Credits	02	Exam. Duration	--

Course objective is to:

- Introduce the concepts of Big Data Analytics and perform basic Hadoop Administration.
- Expose the students to Data warehousing and Visualization in decision making.
- Introduce the concepts of core data mining techniques for data analytics.

Module-1	RBT Level L1,L2,L3	6 Hrs.

Introduction

Introduction to big data, data & Information, Challenges, Technologies, Application, Future Scope, Need for storing the data.

Hadoop – Introduction, Distributed file system, Map reduce programming model, Hadoop ecosystem, HDFS commands

Laboratory Sessions/ Experimental learning: Students will be exposed to Hadoop ecosystem and HDFS commands through hands on experience.

Applications: Data analytics and big data

Video links: https://www.youtube.com/watch?v=iANBytZ26MI

Module-2	RBT Level L1,L2,L3	6 Hrs.

HBase

Introduction, Model, Operations, HBase vs RDBMS, Command, Examples.

Map reduce

Introduction, Simple map, Map function, Reduce function, Grouping, Mapper, Reducer, Example

Laboratory Sessions/ Experimental learning: Students will be exposed to HBase, Commands and examples and will be exposed to Map reduce functions.

Applications: HBase is used for storing the data and running the map functions.

Video links: https://nptel.ac.in/courses/112105123/4

Module-3	RBT Level L1,L2,L3	6 Hrs.

Apache MapReduce

Components, Programming model, Configuring and MapReduce Jobs in IDE

Hive

Introduction, Data types, File formats, Views, Indexes

Laboratory Sessions/ Experimental learning: Students will be exposed to Apache MapReduce and MapReduce Jobs in IDE and Hive through real time examples. **Applications**: Process the vast amount of data. **Video links**: https://www.youtube.com/watch?v=mafw2-CVYnA		
Module-4	**RBT Level L1,L2,L4**	**6 Hrs.**
Pig Latin – Introduction, Grunt shell, Command, Data model **Sqoop** – Introduction, Import data, Query import, Export data **Laboratory Sessions/ Experimental learning**: Students will be exposed to data modeling and export of data through real time examples. **Applications**: Data modeling and exporting the data. **Video links**: https://www.youtube.com/watch?v=_nmYqkk-n9A		
Module-5	**RBT Level L3,L4,L5**	**6 Hrs.**
Oozie – Introduction, Oozie architecture, Oozie action nodes **NoSQL** – Introduction, Storage architecture, Operation, Modifying Data stores, Indexing, Transaction, Parallel processing **Laboratory Sessions/ Experimental learning**: Students will be exposed to data indexing, transaction and parallel processing through hands on sessions. **Applications**: Data indexing, transaction and parallel processing. **Video links**: https://www.youtube.com/watch?v=0buKQHokLK8		

Course outcomes:	
CO1	Explain the concepts of HDFS and MapReduce framework.
CO2	Recognize the role of basic data tools for big data analytics.
CO3	Infer the importance of core data mining techniques for data analytics
CO4	Recognize the role of Business Intelligence, Data warehousing and Visualization in decision making
CO5	Compare and contrast different Text Mining Techniques

Reference Books:	
1.	Anil Maheshwari, "Data Analytics", 1st Edition, McGraw Hill Education, 2017. ISBN-13: 978-9352604180.
2.	Douglas Eadline,"Hadoop 2 Quick-Start Guide: Learn the Essentials of Big Data Computing in the Apache Hadoop 2 Ecosystem", 1stEdition, Pearson Education, 2016. ISBN-13: 978-9332570351.
3.	Eric Sammer,"Hadoop Operations: A Guide for Developers and Administrators",1stEdition, O'Reilly Media, 2012.ISBN-13: 978-9350239261.

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