GURU NANAK DEV ENGINEERING COLLEGE, LUDHIANA
(An Autonomous College u/s 2 (f) and 12 (B) of UGC Act 1956)
DEPARTMENT OF MECHANICAL ENGINEERING

STUDY SCHEME
M.Tech. (Mechanical Engineering)
2019 Admission Batch onwards

1st Semester (GNDEC)										
Category	**Subject Code**	**Subject Name**	**Subject Type (Theory / Practical)**	**Contact Hours/Week**			**Maximum Marks**			**Credits**
				L	**T**	**P**	**Int.**	**Ext.**	**Total**	
Core Course	MME-101	Finite Element Analysis	**Theory**	3	0	0	50	100	150	3
Core Course	MME-102	Advanced Thermodynamics	**Theory**	3	0	0	50	100	150	3
Core Course	MME-103	Decision Making Methods	**Theory**	3	0	0	50	100	150	3
Core Course	MME-104	Computer Integrated Manufacturing	**Theory**	3	0	0	50	100	150	3
Core Course	LMME-101	Finite Element Analysis Laboratory	**Practical**	0	0	4	50	50	100	2
Core Course	LMME-102	Advanced Thermodynamics Laboratory	**Practical**	0	0	4	50	50	100	2
Core Course	LMME-103	Computer Integrated Manufacturing Laboratory	**Practical**	0	0	4	50	50	100	2
Audit Course	MAC-XXX	Audit Course - 1	**Theory**	2	0	0	50	-	50	S/US
Total				**14**	**0**	**12**	**400**	**550**	**950**	**18**
Total Contact Hours/Week = 26										

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DEPARTMENT OF MECHANICAL ENGINEERING

STUDY SCHEME
M.Tech. (Mechanical Engineering)
2019 Admission Batch onwards

2nd Semester (GNDEC)										
Category	**Subject Code**	**Subject Name**	**Subject Type (Theory / Practical)**	**Contact Hours/Week**			**Maximum Marks**			**Credits**
				L	**T**	**P**	**Int.**	**Ext.**	**Total**	
Programme Elective	MME-XXX	Programme Elective – 1	**Theory**	3	0	0	50	100	150	3
Programme Elective	MME-XXX	Programme Elective – 2	**Theory**	3	0	0	50	100	150	3
Programme Elective	MME-XXX	Programme Elective – 3	**Theory**	3	0	0	50	100	150	3
Programme Elective	MME-XXX	Programme Elective – 4	**Theory**	3	0	0	50	100	150	3
Core Course	MRM-101	Research Methodology and IPR	**Theory**	3	0	0	50	100	150	3
Core Course	LMME-104	Decision Making Methods Laboratory	**Practical**	0	0	4	50	50	100	2
Project	LMPME-105	Project	**Practical**	0	0	4	50	50	100	2
Audit Course	MAC-XXX	Audit Course - 2	**Theory**	2	0	0	50	-	50	S/US
Total				**17**	**0**	**8**	400	600	1000	**19**
Total Contact Hours/Week = 25										

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STUDY SCHEME
M.Tech. (Mechanical Engineering)
2019 Admission Batch onwards

3rd Semester (GNDEC)										
Category	**Subject Code**	**Subject Name**	**Subject Type (Theory / Practical)**	**Contact Hours/Week**			**Maximum Marks**			**Credits**
				L	**T**	**P**	**Int.**	**Ext.**	**Total**	
Programme Elective	MME-XXX	Programme Elective - 5	**Theory**	3	0	0	50	100	150	3
Open Elective	MOZZ-XXX	Open Elective -1	**Theory**	3	0	0	50	100	150	3
Pre-Thesis	MPTME-101	Pre-Thesis	**Practical**	0	0	2#+18*	100	100	200	10
Total				**6**	**0**	**20**	**200**	**300**	**500**	**16**
Total Contact Hours/Week = 26										

ZZ-Course Code
XXX-Subject Code
Max. hours for Teacher
* Independent study hours

4th Semester (GNDEC)										
Category	**Subject Code**	**Subject Name**	**Subject Type (Theory / Practical)**	**Contact Hours/Week**			**Maximum Marks**			**Credits**
				L	**T**	**P**	**Int.**	**Ext.**	**Total**	
Thesis	MTME-101	Thesis	**Practical**	0	0	4#+28*	100	200	300	16
Total				**0**	**0**	**32**	**100**	**200**	**300**	**16**
Total Contact Hours/Week = 32										

Max. hours for Teacher
* Independent study hours
Total Credits for the Programme: 69

Note:

A. Student can opt for any five Programme Elective Subjects 1, 2, 3, 4 & 5 respectively from the entire list of Programme Elective Subjects.

B. If a student selects all the five Programme Elective Subjects from the same specialization group of Programme Elective Subjects and also completes his / her project and dissertation in the same field of specialization, then he /she may be **awarded a separate / additional certificate indicating the more concentration in a that particular field of specialization e.g. Manufacturing, Industrial, Design or Thermal Engineering.**

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LIST OF AUDIT SUBJECTS

MAC-101	English for Research Paper Writing
MAC-102	Disaster Management
MAC-103	Sanskrit for Technical Knowledge
MAC-104	Value Education
MAC-105	Constitution of India
MAC-106	Pedagogy Studies
MAC-107	Stress Management by Yoga
MAC-108	Personality Development through Life Enlightenment Skills.

LIST OF PROGRAMME ELECTIVE SUBJECTS

SPECIALIZATION GROUP

(I) DESIGN ENGINEERING

MME-111	Engineering Design Optimization
MME-112	Advanced Vibration Engineering
MME-113	Mechatronics
MME-114	Dynamics of Rotating Machines
MME-115	Experimental Stress Analysis
MME-116	Sustainable Design and Manufacturing
MME-117	Vibration and Noise Control
MME-118	Composite Materials
MME-119	Instrumentation and Control Engineering

(II) THERMAL ENGINEERING

MME-121	Advanced Internal Combustion Engines
MME-122	Design of Steam Turbine
MME-123	Convective Heat Transfer
MME-124	Combustion Engineering
MME-125	Conductive & Radiative Heat Transfer
MME-126	Solar Energy Utilization
MME-127	Design of HVAC systems
MME-128	Design and Optimization of Thermal Systems
MME-129	Advanced Heats and Mass Transfer
MME-130	Computational Fluid Dynamics

(III) MANUFACTURINGENGINEERING

MME-131	Advanced Welding Technology
MME-132	Automation and Robotics
MME-133	Advanced Material Characterization Techniques
MME-134	Rapid Prototyping
MME-135	Advanced Metal Cutting

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MME-136	Advanced Casting Processes
MME-137	Maintenance and Reliability Engineering
MME-138	Jig, Fixtures and Die Design
MME-139	Machine Tool Design

(IV) INDUSTRIAL ENGINEERING

MME-141	Supply Chain Management
MME-142	Product Design and Development
MME-143	Project Appraisal and Management
MME-144	Entrepreneurship
MME-145	Safety Engineering
MME-146	Quality Assurance
MME-147	Materials Management
MME-148	Organization Theory and Behavior
MME-149	Business Policy and Strategies

LIST OF OPEN ELECTIVE SUBJECTS (*for other branches*)

MOME-151	Business Analytics
MOME-152	Industrial Safety
MOME-153	Operations Research
MOME-154	Cost Management of Engineering Projects
MOME-155	Composite Materials
MOME-156	Waste to Energy

Subject Code: MME-101 **Subject Name:Finite Element Analysis**

Programme: M.Tech. (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 1	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits: 3**
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 50%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Course Status:** Core

Prerequisites: Knowledge of Basic concepts of Mechanics and Engineering Mathematics
Additional Material Allowed in ESE: [Scientific Calculator]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Interpret the philosophy behind principles, design and modeling considerations in using finite element analysis.
2	Describe the concept of direct equilibrium method and potential energy method for structural mechanics problems
3	Develop stiffness matrices for spring, truss, beam, plane stress problems and three dimensional problems.
4	Derive the shape function for elements having different nodes.
5	Use mathematical tools to calculate stresses, forces, temperature etc.for given problem.
6	Apply the concepts of FEM in Dynamic problems.

Detailed Contents:

Part-A

1. **Introduction:**Introduction of the FEM and its historical background, Brief overview of the steps used in FEM and various approaches to formulate elemental equations, Review of the concept of stresses, strains, equilibriums, boundary conditions, temperature effect and there relations, Concept and application of Minimum Potential energy method, Rayleigh Ritz method, Galerkin Method and Principle of Virtual Work applied to elasticity problems. **08 Hrs**
2. **Matrix Algebra & Gauss Elimination Method:**Matrix algebra and its different operations, Eigen values and Eigen vectors, Positive definite matrix, Gauss elimination method to solve a large linear equations. **04 Hrs**
3. **1- Dimensional Problem:** Introduction, finite element modeling using bar element, shape functions, Iso, super and sub parametric types of FEM formulation, Potential energy approach and Galerkin method to solve 1-D problems, assembly of elemental equations, types and applications of boundary conditions, higher order 1-D element and their shape functions, its application to 1-D problem, Accounting of temperature effect in 1-D problems. **07 Hrs**
4. **Trusses:**Introduction, 2-D, concept of local and global coordinate system and its transformation matrix, solution of 2-D by the FEM, stress calculations, Accounting of the temperature effect,

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computer programming concepts and its implementation to FEM, sample source code of processing, pre and post processing of the FEM. **07 Hrs**

Part-B

5. **2-D Problem Using Constant Strain Triangles (CST):**Introduction, finite element modeling using CST elements, its shape function, Potential energy approach, solution of the 2-D problem, Accounting of temperature effect, Problem modeling and boundary conditions for symmetrical problems. **05 Hrs**
6. **2-D Isoparamatric Elements and Numerical Integration:** Introduction, Four noded quadrilateral element based FE Modeling and its solution, Numerical integration, concept of weights and gauss points, its values for one point, two point etc. formulae, 2-D & 3-D numerical integration and its application in FEM, Higher order quadrilateral and triangular elements and it's numerical integration. **05 Hrs**

Reference Books

1. Robert D. Cook , David S. Malkus , Michael E. Plesha , Robert J. Witt , *"Concept & Application of Finite Element Analysis"*, John Wiley, 4th Edition , 2001
2. Chandrupatala & Belegundu, *" Introduction to Finite Elements in Engineering"*, PHI, 3rd Edition
3. C S Krisnamoorthy, *"Finite Element Analysis (Theory & programming)"*, TMH, 2nd Edition,2004
4. J N Reddy , *"Finite Element Method"*, McGraw Hill, 3nd Edition .2005

Online Courses and Video Lectures

1. https://nptel.ac.in/courses/112104116/
2. https://nptel.ac.in/courses/112104115/
3. https://nptel.ac.in/courses/105/105/105105041/

Subject Code: MME-102 **Subject Name: Advanced Thermodynamics**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 1	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 60%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Course Status:** Core

Prerequisites: Engineering Thermodynamics, Engineering Mathematics
Additional Material Allowed in ESE: [Scientific Calculator]

On completion of the course the student will have the ability to:

CO #	Course Outcomes (CO)
1.	Analyze thermodynamic systems using advance concepts of First Law of thermodynamics.
2.	Examine and conceptualize the thermodynamic systems using with knowledge of Second law of thermodynamics.
3.	Identify and quantify irreversibility or exergy destruction or entropy generation within various processes and components of thermodynamic cycles and systems.
4.	Comprehend the advanced concepts in thermodynamics with emphasis on thermodynamic relations, properties of single phase systems.
5.	Use thermodynamic relations, properties and phase diagrams for equilibrium and stability of multi-phase multi component systems.
6.	Understand and apply the molecular basis of thermodynamics to determine the thermodynamic properties of thermal systems.

Detailed Contents:

1. **The First Law:** Review ofbasic terms of thermodynamics; Closed Systems: Work Transfer, Heat Transfer; Energy Change: Open Systems. **04 Hrs**

2. **The Second Law:** Closed Systems: Cycle in Contact with One Temperature Reservoir, Cycle in Contact with Two Temperature Reservoirs, Cycle in Contact with Any Number of Temperature Reservoirs, Process in Contact with Any Number of Temperature Reservoirs; Open Systems; Local Equilibrium; Entropy Maximum and Energy Minimum. **07 Hrs**

3. **Entropy Generation, Or Exergy Destruction:** Lost Available Work; Exergy; Irreversibility; Cycles: Heat Engine Cycles, Refrigeration Cycles, Heat Pump Cycles; Non-flow Processes; Steady-Flow Processes; Mechanisms of Entropy Generation: Heat Transfer across a Temperature Difference, Flow with Friction, Mixing; Entropy Generation Minimization: Method, Tree-Shaped Fluid Flow, Entropy Generation Number. **08 Hrs**

4. **Single-Phase Systems:** Simple System; Equilibrium Conditions; Fundamental Relation: Energy Representation, Entropy Representation, Extensive Properties versus Intensive Properties, Euler Equation, Gibbs–Duhem Relation; Legendre Transforms; Relations between Thermodynamic Properties: Maxwell's Relations. **08 Hrs**

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5. **Multiphase Systems:** Energy Minimum Principle: Energy Minimum, Enthalpy Minimum, Helmholtz Free-Energy Minimum, Gibbs Free-Energy Minimum, Star Diagram; Stability of a Simple System: Thermal Stability, Mechanical Stability, Chemical Stability.

06 Hrs

6. **Statistical Thermodynamics:** Introduction: Statistical Foundation of Classical Thermodynamics; Classification Scheme for Statistical Thermodynamics; Why Statistical Thermodynamics; Statistics of Independent Particles:Essential Concepts from Quantum Mechanics.

03 Hrs

Reference Books:

1. A. Bejan, *"Advanced Engineering Thermodynamics"*, John Wiley and sons, 4th Edition, 2016.
2. I. K. Puri and K. Annamalai, *"Advanced Engineering Thermodynamics"*, CRC Press, 2001.
3. Yunus A. CengelAnd Michael A. Boles, *"Thermodynamics- An Engineering Approach"*, 8th Edition, McGraw Hill Education, 2015.
4. Gordon J. Van Wylen and Richard E. Sonntag, *"Fundamentals of Classical Thermodynamics"*, 3rd Edition, John Wiley, 1986.
5. Normand M. Laurendeau, *"Statistical Thermodynamics: Fundamentals and Applications"*, Cambridge University Press, 2005.
6. Chang L. Tien and John H. Linhard, "Statistical Thermodynamics", Hemisphere Publishing Corporation, Revised Edition, 1985.

Subject Code: MME-103 **Subject Name: Decision Making Methods**

Programme: M.Tech. (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 1	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 60%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Course Status:** Core

Prerequisites: Knowledge of Probability and Basic Mathematics
Additional Material Allowed in ESE: [NIL]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Understand different types of decision making tools.
2	Solve a variety of business issues using appropriate decision tools and frameworks.
3	Application of different case studies in real environment.
4	Analyse organizational systems to identify opportunities to improve decision making.
5	Evaluate various approaches in decision making in taking the better decision.
6	Synthesis the decision making on basis of individual and group decision making.

Detailed Contents:

1. **Introduction:** Problem Solving and Decision Making, Types of decisions: Insight, innovation and creativity in decision making, Decision Making Tools and Models, Individual and Group Decision Making, Quantitative and Qualitative Methods in Practice. **05 Hrs**
2. **Probability:**Experiments and the Sample Space, Assigning Probabilities to Experimental Outcomes, Probability Distributions, Random Variables, Discrete Probability Distributions, Uniform Probability Distribution, Normal Probability Distribution, Decision Making with/without Probabilities. **05 Hrs**
3. **Linear Programming:**Linear Programming Problem: Problem Formulation, Graphical, Simplex, Big M Method, Duality, Duality Theorem, Sensitivity Analysis and Interpretation of Solution. **08 Hrs**
4. **Distribution and Sequencing Methods:**Transportation Problem, Assignment Problem, Sequencing Problem, Processing n jobs through one machine, two machine and m machines. **06 Hrs**
5. **Multi-Criteria Decision Methods:**Concept of MCDM, Difference between MCDM and MADM, AHP, TOPSIS, DEA. **08Hrs**
6. **Big Data:**The future of big data and decision making, Case discussion **04 Hrs**

Reference Books

1. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams, Jeffrey D. Camm, James J. Cochran, *"Quantitative Methods for Business"*, 13th Edition, South Western Cengage Learning, Mason, OH, 2015.
2. Prem Kumar Gupta, D S Hira, *" Operations Research"*,6th Edition, S. Chand, New Delhi 2011.
3. R V Rao, *"Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods"*, 1st Edition, Springer-Verlag London,2007.
4. Christian Albright, Wayne L. Winston, *"Business Analytics: Data Analysis and Decision Making"*, 5th Edition, Cengage Learning, 2015.

Subject Code: MME-104 **Subject Name:Computer Integrated Manufacturing**

Programme: M.Tech. (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 1	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 20%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Course Status:** Core

Prerequisites: Computers, manufacturing and automation

Additional Material Allowed in ESE: [Scientific Calculator]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Describe various manufacturing aspects of the machining.
2	Compare NC, CNC and DNC machines
3	Construct part programmes for given sample components
4	Develop an FMS (Flexible Manufacturing System) layout for sample part family, using group technology concepts.
5	Apply computer aided process planning, MRP, CNC part programming.
6	Recognize use of robotics in the field of manufacturing and explain the various robot configurations, robot motions.

Detailed Contents:

1. **Introduction to CAD and CAM**: Brief introduction to CAD and CAM, Manufacturing Planning, Manufacturing control, Concurrent Engineering, CIM concepts; Computerized elements of CIM system, Manufacturing models, Manufacturing Control, Basic Elements of an Automated system, Automation principles and strategies , Lean Production and Just-In Time Production. **06 Hrs**
2. **Computer Aided Process Planning**: Process planning ,Computer Aided Process Planning (CAPP), Logical steps in Computer Aided Process Planning ,Approaches to CAPP,Implementation techniques,the Master Production Schedule ,Material Requirement planning, Capacity Planning, Control Systems, Shop Floor Control Inventory Control, Brief on Manufacturing Resource Planning & Enterprise Resource Planning (ERP). **06 Hrs**
3. **NC and CNC Machines**:Fundamentals of NC Technology; Basic Components of an NC System, NC Coordinate Systems- Motion, Applications of NC,Machine Tool Applications, Computer Numerical Control Features of CNC, The Machine Control Unit for CNC- CAM Software, CNC Applications- Advantages and Disadvantages of CNC, Direct Numerical Control of machine tools. **06 Hrs**

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4. **CNC Part Programming**:Basic terms of part programming , coordinate system, tool functions, basic codes, Description of codes- G codes, M codes, Other codes , Turning centre programming, Machining centre programming, computer aided part programming. **08 Hrs**
5. **Group Technology and FMS**:Group technology-Definition-Advantages and limitations of GT-Part family formation, Classification and coding-, Applications & benefits of GT, Flexible manufacturing system (FMS) -Scope of FMS-FMS compared to other types of manufacturing approaches- Major elements of FMS-Benefits of FMS. **06 Hrs**
6. **Industrial Robotics**:Introduction; configuration of robot, the manipulator, controller power supply, Programming robots –online programming, offline programming, programming languages- robot sensors- robots and computer aided design, Programming robots-Programming methods, Applications of industrial robot. **04Hrs**

Reference Books

1. Mikell.P.Groover *"Automation, Production Systems and Computer Integrated Manufacturing"*, Pearson; 5th Edition, 2018.
2. P. Radhakrishnan S. Subramanyan and V. Raju, *"CAD/CAM/CIM"*, New Age International (P) Ltd, New Delhi, 2nd Edition, 2000.
3. P N Rao, *"CAD/CAM Principles and Applications"*, McGraw Hill India; 3rd Edition,2010.
4. Quesada Robert, *"Computer Numerical Control-Turning and Machining centers"* Prentice Hall, 2014.
5. Farid Amirouche, *"Principles of computer aided design and manufacturing"*, Pearson, 2nd Edition, 2004.
6. M. Groover, *"CAD/ CAM"*, Pearson Education; 1st Edition, 2003.

Subject Code: LMME-101 **Subject Name: Finite Element Analysis Laboratory**

Programme: M.TECH. (ME)	**L:** 0 **T:** 0 **P:**4
Semester: 1	**Teaching Hours:** 48
Theory/Practical: Practical	**Credits:** 2
Internal Marks:50	**Percentage of Numerical/Design/Programming Problems:** N.A.
External Marks: 50	**Duration of End Semester Exam(ESE):** 2hr
Total Marks: 100	**Course Status:** Core

Prerequisites: Fundamental of Strength of materials, CADD

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1.	Understand the general steps used in the finite element analysis to model problems in engineering.
2.	Create and design engineering structures using finite element methods.
3.	Develop the finite element formulations for heat transfer problems
4.	Explore the issues in convergence of solutions using finite element analysis.
5.	Predict the safe design limits for engineering structures.
6.	Communicate effectively through a written report the creation of optimized design of engineering structures.

Detailed Contents:

Each student can use any FEA software to perform the different analysis such as mechanical/ thermal deformation, strain, stresses etc. on various structural elements like bars, trusses, beams, etc as well as various complex mechanical components and assemblies using different shape functions. The various practices can be done by changing boundary conditions for the given application. **48 Hrs**

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Subject Code: LMME-102 **Subject Name: Advanced Thermodynamics Laboratory**

Programme:M.Tech.(ME)	**L:** 0 **T:** 0 **P:** 4
Semester: 1	**Teaching Hours:** 48
Theory/Practical: Practical	**Credits:** 2
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** N.A.
External Marks: 50	**Duration of End Semester Exam(ESE):** 2hr
Total Marks: 100	**Course Status:** Core

Prerequisites: Physics, chemistry, Engineering Thermodynamics, Engineering Mathematics
Additional Material Allowed in ESE: [Scientific Calculator]

On completion of the course the student will have the ability to:

CO #	Course Outcomes (CO)
1.	Perform theoretical and experimental parametric studies of thermodynamic systems.
2.	Visualize the effect of different parameters on the thermodynamic phenomenon.
3.	Analyze thermodynamic systems using advance concepts of First Law and Second Law of thermodynamics.
4.	Identify and quantify irreversibility or exergy destruction or entropy generation within various processes and components of thermodynamic cycles and systems.
5.	Plan the experimentation using methods of design of experiments using available software.
6.	Do single objective optimization of thermodynamic systems using available software

Detailed Contents:

Each student is required to independently work on at least three experimental setups available within the laboratory related to the subject matter of the theory course in this regard in the curriculum. Each student shall do the detailed theoretical and experimental parametric studies and analyze the thermodynamic system using advance concepts of first law and second law of thermodynamics. The thermodynamic system may be related with power producing system such as I.C. engine etc., power consuming system such as vortex tube refrigeration or heating etc. and thermal energy storage such as waste heat recovery using waxes etc. Each student will be able to plan the experimentation using some method of design of experiments and may do single objective optimization using available software. **48 Hrs**

Subject Code: LMME-103 Subject Name: Computer Integrated Manufacturing Laboratory

Programme: M.TECH. (ME)	**L: 0 T: 0 P: 4**
Semester: 1	**Teaching Hours:** 48
Theory/Practical: Practical	**Credits:** 2
Internal Marks:50	**Percentage of Numerical/Design/Programming Problems:** N.A.
External Marks: 50	**Duration of End Semester Exam(ESE):** 2hr
Total Marks: 100	**Course Status:** Core

Prerequisites: Nil

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1.	Understand the concepts of CNC machine tools and CAPP.
2.	Apply JIT and Lean production concept in industry.
3.	Generate part programs using CNC programming.
4.	Evaluate the performance of drilling by CNC drill machine.
5.	Understand and apply the concept of additive manufacturing.
6.	Identify the need for FMS and GT concept in a manufacturing system.

Detailed Contents:

Each student is required to work independently on the non-conventional and CNC machines available in the mechanical laboratory and workshop. Each student shall do the detailed theoretical and experimental studies of machining parameters on any three available machines like electrochemical machine, electro discharge machine, CNC drill machine, CNC milling etc. Each student will plan the experiment using some method of design of experiments. Demonstration and use of 3D printing machine will be done for understanding the concept of additive manufacturing. Each student shall make the program for pick and place of objects.

48Hrs

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Subject Code: MME-115 **Subject Name: Experimental Stress Analysis**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 40 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 10%
External Marks: 100	**Duration of End Semester Exam(ESE):** 03 Hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: NIL

Additional Material Allowed in ESE: [Scientific Calculator]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Understand stress and strain measurements in loaded components.
2	Acquire information's the usage of strain gauges and photo elastic techniques of measurement.
3	Formulate and solve general three dimensional problems of stress-strain analysis especially fundamental problems of elasticity.
4	Analyze the strain gauge data under various loading condition by using gauge rosette method.
5	Evaluate experimentally the location and size of defect in solid and composite materials by using various Non-destructive Testing methods.

Detailed Contents:

UNIT-I **08 Hours**

Extensometers and Displacement Sensors: Principles of measurements; Accuracy, Sensitivity and range of measurements; Mechanical, Optical, Acoustical and Electrical extensometers and their uses, Advantages and disadvantages; Capacitance gauges; Laser displacement sensors.

UNIT-II **12 Hours**

Electrical Resistance Strain Gauges: Principle of operation and requirements, Types and their uses, Materials for strain gauges, Calibration and temperature compensation, cross sensitivity, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators; Rosette analysis; stress gauges, load cells; Data acquisition, six component balance.

UNIT-III **10 Hours**

Photo-Elasticity: Two dimensional photo elasticity, Photo elastic materials; Concept of light – photo elastic effects, stress optic law, Transmission photo elasticity, Jones calculus, plane and circular polariscopes, Interpretation of fringe pattern, Calibration of photo elastic materials, Compensation and separation techniques, Introduction to three dimensional photo elasticity.

UNIT-IV **10 Hours**

Brittle Coating and Moire Techniques: Relation between stresses in coating and specimen; use of failure theories in brittle coating; Moire method of strain analysis.

Reference Books:

1. J.W. Dally and W.F. Riley, "*Experimental Stress Analysis*", McGraw Hill Inc., 1998.
2. S. Singh, "*Experimental Stress Analysis*", Khanna Publishers, 1996
3. L.S.Srinath, M.R. Raghavan, K. Lingaiah, G. Gargesa, B.Pant, and K. Ramachandra, "*Experimental Stress Analysis*", Tata Mc Graw Hill, 1984.

Subject Code: MME-126 **Subject Name: Solar Energy Utilization**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**40%
External Marks: 100	**Duration of End Semester Exam(ESE):** 03 Hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Engineering Mathematics, Basics of Solar Energy
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Evaluate the estimation and measurement of radiation on flat and tilted surfaces.
2.	Understand the physical conversion of solar radiation into heat and working of flat plate collector.
3.	Analyze orientation and sun tracking system and understand the working of focusing type of collectors.
4.	Understand various types of solar energy storage systems.
5.	Apply the principles of solar cooking, solar desalination, solar ponds, solar space heating, solar industrial process heating and solar power generation.

Detailed Contents:

UNIT-I **07 Hours**

Solar Radiations: The sun, the solar constant, spectral distribution of extraterrestrial radiations, variation of extraterrestrial radiations, solar angles and solar time, direction of beam radiations, ratio of beam radiation on titled surface to that of horizontal surface, extraterrestrial radiation on horizontal surface.

UNIT-II **10 Hours**

Theory of Flat Plate Collectors: General description of flat plate collectors, the basic flat plate energy balance equation, collector overall heat transfer coefficient, temperature distribution between tubes and collector efficiency factor, temperature distribution in flow direction, collector heat removal factor and flow factor, effect of dust and shading, heat capacity effects in flat plate collectors, collector performance, collector performance tests, practical considerations for flat plate collectors.

UNIT-III **08 Hours**

Concentrating Collectors: Collector configurations, concentration ratio, thermal performance of concentrating collectors, orientation and absorbed energy for collectors, performance of collectors, paraboloidal concentrators, and central receiver collectors.

UNIT-IV **11 Hours**

Energy Storage and Applications: Process loads and solar collector output, energy storage in solar process systems, water storage, packed bed storage, phase change energy storage, chemical energy storage, electric storage. Introduction and principle of operation of solar cooker, solar air heater, solar water heater, solar distillation, solar pond, solar thermal power generation, Solar PV system.

Reference Books:

1. G.D. Rai, "*Solar Energy Utilization*", Khanna Publishers, 2010.
2. S.P. Sukhatme, "*Solar Energy*", Tata McGraw Hill Publishers, 2008
3. H.P. Garg, "*Treatise on Solar Energy*", John Willey & Sons, 2006.
4. A. Mani, S. Rangarajan, "*Handbook of Solar Radiation Data for India*", Allied Publishers, 2006.
5. J.A. Duffie and Beckman, "*Solar Energy Thermal Process*", John Wiley and Sons, 2006.
6. J. Sheng Hsieh, "*Solar Energy Engineering*", Prentice- Hall, 2007.

Subject Code: MME-130 **Subject Name: Computational Fluid Dynamics**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 50%
External Marks: 100	**Duration of End Semester Exam(ESE):** 03Hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Fluid Dynamics, Calculus, Matrix Algebra
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO #	Course Outcomes
1.	Understand the concept of numerical modeling, applications of CFD to various engineering fields, importance of computational investigation over experimentation.
2.	Apply conservation principles to derive various flow-governing equations, their mathematical nature and various boundary conditions.
3.	Understand basic discretization techniques: finite difference and finite volume methods, applied to model system of equations.
4.	Analyze various numerical schemes: concept of consistency, stability and convergence, error and stability analysis.
5.	Solve linear algebraic equations by TDMA, QUICK scheme,SIMPLE algorithm for various types of fluid flow problems.

Detailed Contents:

UNIT-I **10Hours**

Introduction to CFD and Governing Flow Equations: Basic concept of Computational Fluid Dynamics, CFD Applications, Numerical, Analytical and Experimental investigations, modeling and Experimentation and their merits and demerits, working of CFD code.

Governing Flow Equations: Fundamental principles of conservation, Conservation of mass, Conservation of linear momentum: Navier-Stokes equation, Conservation of Energy, concept of turbulence modeling; General scalar transport equation.

Mathematical classification of Partial Differential Equation: physical meaning of elliptic, parabolic and hyperbolic partial differential equations; well posed boundary value problem, possible types of boundary conditions.

UNIT-II **10 Hours**

Fundamental of Discretization: Nature of numerical methods, Discretization concept/principles, Methods of deriving the discretization equations,Grid generation techniques

Properties of Numerical Methods: Conservation, Boundedness, Convergence, Consistency, stability, Accuracy, Transportiveness.

Finite Difference Method (FDM): Finite difference approximations, Taylor series expansion (1^{st} and 2^{nd} order derivatives), applications to conduction and advection-diffusion problems.

Finite Volume Methods: Basics methodology, finite volume discretization, approximation of surface and volume integrals; Interpolation methods: Upwind interpolation, linear interpolation,quadratic upwind interpolation (QUICK); Illustrations through 1-D Steady State Diffusion and convection-diffusion Problems: Physical consistency, Source term linearization, Implementation of boundary conditions.

UNIT-III **08 Hours**

Solution of Systems of Linear Algebraic Equations: Criteria for unique solution, infinite number of solutions and no solution, Guass Elimination method: Forward elimination and backward substitution, L-U decomposition technique, Tridiagonal matrix algorithm (TDMA): Thomas algorithm, Iteration methods: Jacobi's method and Gauss Siedel method

UNIT-IV **08 Hours**

Unsteady State Problems: Single and multilevel methods; predictor-corrector methods; stability analysis; Application to Generic Transport Equation: implicit, fully explicit and Crank-Nicholson scheme,

Navier Stokes Equations: Discretization ofconvective, viscous, pressure and body terms, staggered grid and Collocated grid, SIMPLE Algorithm

Reference Books:

1. S. V. Patankar, "Numerical *Heat transfer and Fluid Flow*," Taylor and Francis.
2. H.K. Versteeg and W. Malalasekera, "*An Introduction to Computational Fluid Dynamics*, The finite volume approach" Pearson Publishing House.
3. J. D. AndersinJr, "*Computational Fluid Dynamics*", McGraw Hill, Publishing House.
4. J.H. Ferziger and M. Peric, "*Computational Methods for Fluid Dynamics*", Springer.
5. C. Hirch, "Numerical *Computation of Internal and External Flow*", Elsevier.
6. J. C. Tannehill, Dale A. Anderson and R. H. Pletcher, "*Computational Fluid Mechanics and Heat Transfer*", Taylor and Francis.

E-Books and online learning material:

1. http:// www.cfd-online.com[Access Date: 25-02-2020]
2. https://www.ansys.com/en-in/academic/free-student-products [Access Date: 25-02-2020]

Online Courses and Video Lectures:

https://nptel.ac.in/courses/cfd[Access Date: 25-02-2020]

CFD video course by Prof. S. Chakraborty, Department of Mechanical Engineering IIT Kharagpur
CFD video course by Prof. GautamBiswas IIT Kanpur,
CFD video course by Prof. M.Ramakrishna, Department of Aerospace Engineering IIT Madras
CFD video course by Prof. K.M.Singh, Department of Mechanical Engineering IIT Roorkee

Subject Code: MME-132 **Subject Name: Automation and Robotics**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 10%
External Marks: 100	**Duration of End Semester Exam(ESE):** 03 Hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Basic knowledge of engineering mathematics and automation
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Identify potential areas for automation and justify need for automation
2.	Select suitable major control components required to automate a process or an activity.
3.	Explain the basic principles of robotic technology, configurations, control and programming of robots.
4.	Choose the appropriate sensor and machine vision system for a given application.
5.	Design hydraulic and pneumatic circuits for industrial applications

Detailed Contents:

UNIT-I **10 Hours**

Automation: Automation in production system; principles and strategies of automation, basic elements of an automated system, advanced automation functions, levels of automations; Automated flow lines, methods of work-part transport, transfer mechanism, and automation for machining operations; Analysis of automated flow lines; General terminology and analysis, Analysis of transfer lines, partial automation. Automated inspection principles and methods; Sensor technologies for automated inspection; Machine vision; Micro PLC, programming a PLC, logic functions, input & output modules.

UNIT-II **08 Hours**

Material Handling and Assembly Systems: The material handling function; Types of material handling equipment; Conveyor systems; Automated guided vehicle systems. Automated storage systems; Storage system performance; Handling and storage with manufacturing. Types of automated assembly systems, part feeding devices.

UNIT-III **08 Hours**

Pneumatic and Hydraulic Control: Introduction to control system; Types of control system and their utility; Valve control, pressure flow relationship for hydraulic valves, valve configurations and constructions; Circuit design, pneumatic valves, hydraulic and pneumatic drives; Electro pneumatic components operation and Application.

UNIT-IV **10 Hours**

Robotics: Geometric and control classification of robots; Robot coordinate systems and manipulator kinematics; Robot elements: drive systems, control systems, end effectors, gripper actuators and gripper design. Robot control: fundamental principles, classification, position, path and speed control systems, adaptive control. Robot programming: level of robot programming, language based programming, task level programming. Robot economics, robot integration with CAD/CAM/CIM, vision sensors, robot visual sensing tasks, detecting partially visible objects.

Reference Books:

1. M.P. Grover, "*Automation, Production Systems and Computer Integrated Manufacturing*", Pearson Education, 2016.
2. W. John, Mc-millan, "*Programmable Logic Controller: Principles and Applications*", Prentice Hall India Learning Private Limited; 2002.
3. M. Groover, Mitchell Weiss, Nagel Octrey, "*Industrial Robotics*", McGraw Hill Inc., 1986.
4. C. Ray. Asfahl , "*Robots & Manufacturing Automation* ", Wiley, 2010.
5. S.R. Majumdar, "*Pneumatic Systems*" Tata Megraw Hill Pub. Co. Ltd. 1995.
6. R. Srinivasan , "*Hydraulic and Pneumatic Control*", McGraw Hill Education 2008.

Subject Code: MME-133 Subject Name: Advanced Material Characterization Techniques

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** 10%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3Hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: NIL
Additional Material Allowed in ESE: NIL

On Completion of the course, the student will have the ability to:

CO #	Course Outcomes
1.	Understand the need of characterization in concern with mechanical properties.
2.	Apply various techniques to study the internal structure of the material.
3.	Recognize the spectroscopic behavior of the material under various conditions of material development.
4.	Evaluate and analyze the performance of material under the effect of temperature cycles.
5.	Conclude upon the method of development by studying the behavior of the material under various conditions.

Detailed Contents:

UNIT-I **05 Hours**

Introduction to Characterization of Materials: Introduction to characterization, importance and its applications; review of mechanical properties like tensile & flexural moduli, strength, fatigue, creep, fracture toughness and hardness in concern with characterization.

UNIT-II **10 Hours**

Diffraction and Microscopic Techniques: X-ray (XRD), electron and neutron diffraction; optical, electron: Scanning electron microscopy (SEM) and transmission electron microscopy (TEM), electron microprobe analysis, scanning probe methods: Scanning Tunnel Microscopy (STM), Atomic force microscopy (AFM), Scanning Probe Electrochemistry (SPE).

UNIT-III **12 Hours**

Optical, Electron and Spin Resonance Spectroscopes: Ultraviolet (UV-visible), Infrared Spectroscopy (IR), Fourier Transform Infrared Spectroscopy (FTIR) and Raman spectroscopy; Auger and photoelectron spectroscopy, Nuclear magnetic resonance (NMR); Electron Spin Resonance (ESR) and Mossbauer spectroscopy.

UNIT-IV **09 Hours**

Chromatographic and Thermal Analysis Techniques: Gas and liquid Chromatography: Introduction, its types, advantages and disadvantages; Thermo-gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Thermo-Mechanical Analysis (TMA) and Dynamic Mechanical Analysis (DMA).

Reference Books:

1. S. Zhang , Lin Li, Ashok Kumar,. "*Materials Characterization Techniques*". CRC Press, 2008

2. Yang Leng,. "*Materials Characterization: Introduction To Microscopic and Spectroscopic Methods*" Singapore: John Wiley & Sons, 2008
3. D. Briggs, M.P. Seah, "*Practical Surface Analysis by Auger and X-Ray Photoelectron Spectroscopy*" Wiley, 1990
4. P. R. Khangaonkar, "*An Introduction to Material Characterization*", Penram Intl. Publishing (India) Pvt. Ltd., 2008.
5. N.P. Cheremisinoff. "*Polymer Characterization- Laboratory Techniques and Analysis*", *Elsevier*, William Andrew 1996
6. E. N. Kauffmann, "C*haracterization of Materials*", 2 Volume Set, Wiley-Blackwell, 2003.

Subject Code: MME-141 **Subject Name: Supply Chain Management**

Programme: M.Tech. (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** NIL
External Marks: 100	**Duration of End Semester Exam(ESE):** 03Hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: NIL

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Understand the importance of the basics of Supply Chain Analytics and Optimization.
2.	Analyse the level of uncertainty associated with the supply of products and services to targeted customer segments and justify the choice of a supply chain strategy and its fit with competitive strategy.
3.	Explain the role and applications of Descriptive Analytics in a Supply Chain.
4.	Explain the role and applications of Predictive Analytics in a Supply Chain.
5.	Explain the role and applications of Big Data Analytics in a Supply Chain.

Detailed Contents:

UNIT-I **07 hours**

Introduction: Objectives of supply chain management; key components of supply chain i.e. sourcing, distribution strategy, customer service strategy; Supply chain management as integrated logistics, generic activities, architecture of supply chain, future potential of supply chain management; Corporate profitability: Link to supply chain, evaluation of SCM strategies, customer focus in SCM, Inventory and logistic management, vendor management, Just-in-Time (JIT).

UNIT-II **10 hours**

Quality Management: Inherent link to SCM: Suppliers development, distribution channel, re-engineering of supply chain; IT – enabled supply chain: electronic data interchange, enterprise resource planning, implementation of IT; Scope of emerging distributed cooperative tele-manufacturing over internet.

UNIT-III **08 hours**

Organizational Issues: Application of knowledge management for effectiveness SCM; Social interactions and linking of functional units in a supply chain; Combined core competency of SC: global sourcing, technology and tools – essential enablers, framework for managing knowledge intensive supply chian.

UNIT-IV **11 hours**

Recent Trends in SCM: Tierisation of supplies; Reverse logistics; JIT II, Milk Round System (MRS); bar coding, Hub and Spoke Concept and other latest concepts.

Reference Books:

1. R. B. Chase, Ravi Shankar, F. Robert Jacobs, and Nicholas Aquilano, " *Operations & Supply Management",* McGraw-Hill, 2010.
2. S.Chopra and Peter Meindel, "*Supply Chain Management, Strategy, Planning, and Operation*", Prentice Hall, 2010.
3. Wisner, Leong and Tan, "*Principles of Supply Chain Management*", Thomson South-Western, 2005.

4. Lambert, Douglas M., Stock, James R., Ellram, Lisa M., "*Fundamentals of Logistics Management*", McGraw Hill,1998.
5. J. F. Shapiro, "*Modeling the Supply Chain*", Duxbury Thomson Learning, 2001
6. R.B. Handfield and E.L. Nochols, Jr., "*Introduction to Supply Chain Management*, Prentice Hall, 1999.

Subject Code: MRM-101 **Subject Name: Research Methodology and IPR**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**60%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3Hours
Total Marks: 150	**Course Status:** Compulsory

Prerequisites: NIL

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Understand research problem formulation.
2.	Analyze research related information
3.	Follow research ethics
4.	Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5.	Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

Detailed Contents:

UNIT-I **07 Hours**

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

UNIT-II **05 Hours**

Effective literature studies approaches, analysis Plagiarism, Research ethics.

UNIT-III **06 Hours**

Effective Technical Writing: How to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

UNIT-IV **06 Hours**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT-V **06 Hours**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

UNIT-VI **06 Hours**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

Reference Books:

1. S. Melville and W. Goddard, "*Research Methodology: An Introduction for Science and Engineering Students*", Juta Academic, 1996

2. R. Kumar, "Research Methodology: *A Step by Step Guide for Beginners*", SAGE, 2014.
3. Halbert, "*Resisting Intellectual Property*", Taylor & Francis Ltd, 2007.
4. Mayall, "*Industrial Design*", McGraw Hill, 1992.
5. Niebel , "*Product Design*", McGraw Hill, 1974.
6. Asimov, "*Introduction to Design*", Prentice Hall, 1962.

Subject Code: LMME-104 **Subject Name: Decision Making Methods Laboratory**

Programme: M.Tech.(ME)	**L:** 0 **T:** 0 **P:** 4
Semester: 2	**Teaching Hours:** 48 Hours
Theory/Practical: Theory	**Credits:** 2
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:** N.A.
External Marks: 50	**Duration of End Semester Exam (ESE):** 02 Hours
Total Marks: 100	**Course Status:** Core

Prerequisites: Microsoft Office (Excel, Word), knowledge of basic mathematics
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have ability to:

CO #	Course Outcomes
1.	Understand different decision making tools.
2.	Solve operation research problems.
3.	Analyse and selection best criteria, and obtain the most appropriate combination of criteria in conjunction with the real industrial requirement.
4.	Evaluate wide range of alternative options, and select one based on a set of conflicting criteria.
5.	Apply decision making techniques in various situations of manufacturing environments.

Detailed Contents:

Each student is required to work on independent decision making problems. The each student shall collect the data and apply different decision making techniques for a given engineering application such as material selection, evaluation of alternative product designs, cutting fluid selection, evaluation and selection of flexible manufacturing systems, selection of machine tool, robot, material handling equipment, rapid prototyping process, vendor selection, engineering equipment, selection of software for design and manufacturing applications etc. Apply the following decision making techniques for the selected problem based upon literature survey:

Multi Criteria Decision Making (MCDM) Methods

- Simple Additive Weighting (SAW) Method
- Weighted Product Method (WPM)
- Weighted Aggregated Sum Product Assessment (WASPAS)
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
- Evaluation Based on Distance from Average Solution (EDAS)

Weights of Significance Methods

- Equal Weights Method
- Analytic Hierarchy Process (AHP)
- Entropy Weights Method
- Standard Deviation Method

Excel Solver:

- Excel includes a tool called solver that uses techniques for all kinds of decision problems.

Subject Code: MOME-156 **Subject Name: Waste to Energy**

Programme: M. Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 1	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**20%
External Marks: 100	**Duration of End Semester Exam(ESE):** 03 Hrs
Total Marks: 150	**Course Status:** Elective

Prerequisites: NA

Additional Material Allowed in ESE: Scientific Calculator

Note: There should be at least one visit to a waste to energy plant during the course.

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1	Understand waste and technologies for generation of energy from solid waste.
2	Know different types of biomass gasifiers.
3	Design biomass combustors.
4	Apply biogas resources for production of energy from biomass.
5	Manage e-waste on basis of Governmental regulations.

Detailed Contents:

1. **Introduction to Energy from Waste**: Classification of waste as fuel – Agro based, Forest residue, Industrial waste; Energy content of waste; MSW- Waste minimization and recycling of municipal waste, Segregation of waste, Size Reduction, Managing Waste; Status of technologies for generation of Energy from Waste Treatment; Conversion devices – Incinerators, gasifiers, digestors. **06 Hrs**
2. **Biomass Gasification**: Gasifiers – Fixed bed system, Downdraft and updraft gasifiers; Fluidized bed gasifiers –construction and operation; Gasifier burner arrangement for thermal heating; Gasifier engine arrangement and electrical power; Mathematical Design and modeling of fixed bed gasifier; Equilibrium and kinetic consideration in gasifier operation. **08 Hrs**
3. **Biomass Combustion**: Biomass stoves – Improved chullahs, types; Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors; Construction and operation of all the above biomass combustors. **08 Hrs**
4. **Biogas:** Properties of biogas (Calorific value and composition); Biogas plant technology and status; Bio energy system – Design, analysis and constructional features; Biomass resources and their classification, Biomass conversion processes: Thermo chemical conversion, Direct combustion; Types of biogas Plants and their Applications; Alcohol production from biomass; Bio diesel production; Biomass energy programme in India. **08 Hrs**
5. **E-waste:** E-waste in the global context; Growth of Electrical and Electronics industry in India; Environment concerns and health hazards; Recyling e-waste; Management of e-waste; Government regulations on e-waste management. **06 Hrs**

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Text Books

1. Ashok V. Desai, *"Non Conventional Energy"*, Wiley Eastern Ltd., 1990.
2. K. C. Khandelwal, and S. S. Mahdi, *"Biogas Technology - A Practical Hand Book"*, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. C. Y. WereKo-Brobby and E. B. Hagan, *"Biomass Conversion and Technology"*, John Wiley & Sons, 1996.
4. Nicholas P. Cheremisinoff, *"Handbook of Solid Waste Management and Waste Minimization Technologies"*, An Imprint of Elsevier, New Delhi. 2003.
5. C. S. Rao, *"Environmental Pollution Control Engineering"*, Wiley Eastern Ltd. New Delhi, 1995

Reference Books:

1. *"E-Waste in India: Research Unit"*, Rajya Sabha Secretariat, New Delhi, June 2011
2. G Rich et al. *"Hazardous Waste Management Technology"*, Podvan Publishers, 1987.
3. K. L. Shah, *"Basics of Solid and Hazardous Waste Management Technology"*, Prentice Hall, 2000.

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Subject Code: MME-124 **Subject Name: Combustion Engineering**

Programme: M. Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester:2/3	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**60%
External Marks: 100	**Duration of End Semester Exam(ESE):** 03 Hrs
Total Marks: 150	**Course Status:** Elective

Prerequisites: Engineering Thermodynamics, Fluid Dynamics, Heat Transfer
Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO #	Course Outcomes
1	Understand the fundamental concepts of combustion science and engineering
2	Formulate the rate of reaction on the basis of chemical kinetics
3	Comprehend the flame types, propagation, stability and combustion mechanism/Modeling for SI and CI engines
4	Design liquid fuel combustion process in oil furnaces/ boiler, gas turbine and direct injection systems
5	Understand the solid fuel combustion in context with fluidized bed fundamentals

Detailed Contents:

1. **Combustion Thermodynamics**; Review of basic thermodynamics and gaseous mixtures, stoichiometry, the First and Second Laws of Thermodynamics applied to combustion Enthalpy of formation; Enthalpy of reaction; Heating values; First & second laws; Analysis of reaction system, Chemical equilibrium, Equilibrium composition; Adiabatic & equilibrium, flame temperature. **06 Hrs**
2. **Fundamentals of Combustion Kinetic:** Governing equations species, momentum and energy conservation equations for multi component reacting systems. Combustion products in equilibrium; Rate of reactions; Chain reactions; Opposing reactions; Consecutive reactions; Competitive reactions. **06 Hrs**
3. **Flames and Combustion in SI and CI engines:** Laminar/Turbulent flame structure; Theories of flame propagation & calculation of flame speed measurements. Stability limits of laminar flames; Flammability limits & quenching distant, Mechanism of flame stabilization, flame quenching, Diffusion flames; Comparison of diffusion with premixed flame, combustion of gaseous fuel, Thermodynamics and Spark-Ignition (SI) / Compression Ignition (CI) engine modeling, SI/CI engine fuel thermo chemistry, SI/CI combustion chemistry and emission. Ignition delay and knock; Combustion chamber for SI and CI engines- Construction and Performance aspects; M-combustion chamber; Latest combustion chamber and technology. **12 Hrs**
4. **Combustion of Liquid Fuel Droplet**: Fuel atomization; Types of injectors; Spray formation and characteristics; Design of Oil – fired furnace/Boiler combustion; Gas turbine spray combustion; Direct injection engine combustion; Detonation of liquid gaseous mixture. **06 Hrs**

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5. **Combustion of Solid Fuels**: Coal combustion; Combustion of pulverized coal; Stabilization of pulverized coal combustion; Design consideration of coal burners; Combustion generated pollution. Fluidized bed combustion fundamentals, combustion in bubbling bed, atmospheric fluidized bed, circulating fluidized beds and pressurized fluidized bed combustion. **06 Hrs**

Text Books:

1. S. R. Turns, "*An introduction to Combustion*", McGraw-Hill Ltd., 3rd Edition, 2012.
2. J. B. Heywood, "*Internal Combustion Fundamentals*", McGraw-Hill Ltd., 2nd Edition, 2012
3. G. L. Borman, K. W. Ragland, "*Combustion Engineering*", McGraw-Hill Ltd., 1998.
4. F. E. Mahallawy, S. E. Din Habik, "*Fundamentals and Technology of Combustion*", Elsevier Sci. Ltd., 1st Edition, 2002
5. E. L. Keating, "*Applied Combustion*", CRC Press, 2nd Edition, 2007
6. K. K. Kuo, "*Principles of Combustion*", Wiley-Interscience Ltd., 2nd Edition, 2005.

Reference Books:

1. Glassman, R. A. Yetter, "*Combustion*", Academic Press, 4th Edition, 2008.
2. C. K. Law, "*Combustion Physics*", Cambridge University Press, 2006
3. T. Poinsot, D. Veynante, "*Theoretical and Numerical Combustion*", R.T. Edwards, Inc., 3rd Edition, 2011.
4. B. Lewis, G. von Elbe, "*Combustion Flames and Explosions of Gases*", Academic Press, 3rd Edition, 1987.
5. F. A. Williams, "*Combustion Theory*", Addison Wesley, 2nd Edition,1985

E-Books and online learning material

1. http://www.eia.doe.gov (Energy Information Administration, U.S. Department of Energy)
2. http://www.combustioninstitute.org (The Combustion Institute)
3. http://crf.sandia.gov (Combustion Research Facility, Sandia National Labs)
4. http://webbook.nist.gov/chemistry/fluid (NIST online thermodynamic database)
5. http://www.sae.org (SAE International – Society of Automotive Engineers)
6. http://www.aiaa.org (American Institute of Aeronautics and Astronautics)

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Subject Code: MME-201 **Subject Name: Advanced I.C. Engines**

Programme: M. Tech.(ME)	**L:** 4 **T:** 0 **P:** 0
Semester: 2nd/3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 40	**Percentage of Numerical/Design/Programming Problems:** 10%
External Marks: 60	**Duration of End Semester Exam(ESE):** 03 Hrs
Total Marks: 100	**Course Status:** Elective

Prerequisites: NA

Additional Material Allowed in ESE: Design Data Book [Scientific Calculator]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Understand the basic components of I.C engines (S.I & C.I engines).
2	Understand the working principles of I.C engines.
3	Know about what are the emission norms of I.C engine.
4	Understand what the alternate fuels are used in the I.C engine.
5	Know about emission norms of the alternate fuels.
6	Know about the recent trend in I.C engine and what are the modification in engine for the future.

Detailed Contents:

Part-A

1. **Spark Ignition Engines:** External and internal combustion engines; Mixture requirements; Fuel injection systems – Mono point, Multipoint & Direct injection; different models of combustion – Normal and Abnormal combustion;modeling of combustion. **03 Hrs**
2. **Compression Ignition Engines:** Diesel Fuel Injection Systems, Knocking – Factors affecting knock, Direct and Indirect injection systems, Combustion chambers, Fuel Spray behavior – Spray structure and spray penetration, Air motion, Introduction to Turbocharging. **03 Hrs**
3. **Engine Exhaust Emission Control:** Pollutant Sources, Formation of Carbon Monoxide, Unburnt hydrocarbon, Oxides of Nitrogen, Smoke and Particulate matter, Methods of controlling Emissions, Catalytic converters, Selective Catalytic Reduction and Particulate Traps, Methods of measurement, Emission norms and Driving cycles. **05 Hrs**

Part-B

4. **Alternate Fuels:** Alcohol, Hydrogen, Compressed Natural Gas, Liquefied Petroleum Gas and Bio Diesel - Properties, Suitability, Merits and Demerits, Engine Modifications. **08 Hrs**
5. **Recent Trends:** Air assisted Combustion, Homogeneous charge compression ignition engines, Variable Geometry turbochargers, Common Rail Direct Injection Systems, Hybrid Electric Vehicles, NOx Adsorbers, Onboard Diagnostics. **02 Hrs**

Reference Books

1. K. K. Ramalingam, *"Internal Combustion Engine Fundamentals"*, Scitech Publications, 2002.
2. V. Ganesan, *"Internal Combustion Engines"*, Third Edition, Tata Mcgraw-Hill, 2007.

3. J. Webster, *"Auto Mechanics"*,Collier Macmillan Publishers,London,1980.
4. R.K. Rajput, , *"A Text Book of Internal Combustion Engines"*, Laxmi Publishers,2005.
5. J.B. Heywood, *"Internal Combustion Engine Fundamentals"*, McGraw-Hill Education, 2018.

Subject Code: MME-111 **Subject Name: Engineering Design Optimization**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**60-70
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Understand the characteristics of different design optimization processes and models in real-life environments.
2.	Application of different unconstrained and constraint gradient-based optimization types in real-life environments.
3.	Formulate an optimization problem and identify key characteristics to classify optimization problems and algorithms.
4.	Implement the concepts behind state-of-the-art constrained optimization algorithms and use them to solve real engineering problems.
5.	Identify and apply the appropriate methods for some computational models.

Detailed Contents:

1. **Introduction:** Design Optimization Process, Optimization Problem Formulation, Optimization Problem Classification, Optimization Algorithms, Selecting an Optimization Approach. The First Problems: Optimizing Length and Area, Optimization Revolution: Derivatives and Calculus. The Birth of Optimization Algorithms. The Last Decades, Toward a Diverse Future. **5Hrs**
2. **Numerical Models and Solvers:** Model Development for Analysis versus Optimization, Modeling Process and Types of Errors, Numerical Models as Residual Equations, Discretization of Differential Equations, Numerical Errors, Overview of Solvers, Rate of Convergence, Newton-based Solvers, Models and the Optimization Problem. **5Hrs**
3. **Unconstrained and Constraint Gradient-Based Optimization:** Fundamentals, Two Overall Approaches to Finding an Optimum, Line Search, Search Direction, Trust-Region Methods, Constrained Problem Formulation, Understanding n-Dimensional Space, Optimality Conditions, Penalty Methods. **8Hrs**
4. **Computing Derivatives:** Derivatives, Gradients, and Jacobians, Overview of Methods for Computing Derivatives, Symbolic Differentiation, Finite Differences, Complex-Step, Algorithmic Differentiation, Implicit Analytic Methods—Direct and Adjoint, Sparse Jacobians and Graph Coloring. **6Hrs**
5. **Gradient-Free and Discrete Optimization:** When to Use Gradient-Free Algorithms, Classification of Gradient-Free Algorithms, Nelder–Mead Algorithm, Discrete Optimization, Binary, Integer, and Discrete Variables, Avoiding Discrete Variables, Branch and Bound .**6Hrs**
6. **Multiobjective Optimization and Surrogate-Based Optimization:** Multiple Objectives, Pareto Optimality, Solution, Surrogate-Based Optimization, When to Use a Surrogate Model, Sampling, Constructing a Surrogate, Optimization under Uncertainty, Robust Design, Reliable Design. **6Hrs**

Text Books:

1. Martins, Joaquim RRA, and Andrew Ning, *Engineering design optimization*. Cambridge University Press, 2021.
2. Deb, K., 2012. *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd.
3. Singerusu S. Rao, *Engineering Optimization -Theory and Practice*, New Age.
4. Johnson Ray C, *Optimum Design of Mechanical Elements*, Wiley, John & Sons
5. Goldberg D. E. Addison, *Genetic Algorithms in search, Optimization and Machine*, Wesley, New York.

Reference Books:

1. Gero, J. ed., 2012. *Design optimization*. Elsevier.
2. R., Pannerselvam, *Design and Analysis of Algorithms*, Prentice Hall of India, New Delhi, 2007.

E-Books and Online Learning Material

1. https://www.elsevier.com/books/design-optimization/gero/978-0-12-280910-1
   Accessed in June 2021
2. https://www.igi-global.com/book/design-optimization-mechanical-engineering-products/180658
   Accessed in June 2021

Online Courses and Video Lectures

1. https://nptel.ac.in/courses/112/106/112106064/ Accessed in June 2021
2. https://onlinecourses.nptel.ac.in/noc21_ce60/preview Accessed in June 2021
3. https://onlinecourses.nptel.ac.in/noc20_ma32/preview Accessed in June 2021

Subject Code: MME-112 **Subject Name: Advanced Vibration Engineering**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**60-70
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Understand basic terms, definitions and principles of vibration analysis.
2.	Understand the general procedure to carry out Vibration analysis.
3.	Analysis methods for field problem using various methods.
4.	Control vibrations in the system.
5.	Measure the experimental data and find out its analysis.

Detailed Contents:

1. **Fundamentals of Vibration:** Basic concepts of Vibration, Vibration Analysis Procedures, Harmonic analysis, Free and Forced Vibration analysis of single degree of freedom system, Methods of analysis, single degree of freedom systems with viscous, Coulomb and Hysteresis damping, Vibration under general forcing conditions. **6Hrs**
2. **Two Degree Freedom System:** Introduction-Free and Forced Vibration Analysis of Undamped and Damped Systems, Bending Vibration of Two Degrees of Freedom System, Coordinate Couplings And Principal Coordinates, Stability Analysis. **6Hrs**
3. **Multi-Degree Freedom System and Continuous System:** Far Coupled and Closed Coupled Systems, Generalized Coordinates and Generalized Forces, Lagrange's Equation, Eigen Value Problem, Orthogonality of Mode Shapes, Modal Analysis, Forced Vibration using Modal Analysis. **6Hrs**
4. **Numerical Methods: Approximate Methods:** Dunkerley, Rayleigh's, and Holzer Method, Matrix Condensation Scheme, Component Mode Synthesis. **4Hrs**
5. **Continuous Systems:** Transverse Vibration of a String or Cable, Longitudinal Vibration of a Bar or Rod, Torsional Vibration of a Shaft or Rod, Lateral Vibration of Beams. **5Hrs**
6. **Vibration Control:** Vibration Isolation, Vibration Absorbers, Static and Dynamic Balancing-Balancing machines-Field balancing, Vibration Control by Design Modification, Vibration as condition Monitoring tool. **5Hrs**
7. **Vibration Measurement and Applications:** Transducers, Vibration Exciters, Vibration, Measuring Instruments, Signal Analysis, Experimental Modal Analysis, Machine Condition Monitoring and Diagnosis. **4Hrs**

Text Books:

1. Rao S. S., Mechanical Vibrations, Pearson, sixth edition 2018.
2. Inman D. J., Engineering Vibration, 4th Edition, Pearson, 2014.
3. Kelly S. G., Fundamentals of Mechanical Vibrations, McGraw Hill, 2nd edition,2000.

4. Meiorvtch Leonard, Elements of Mechanical Vibration Ananlysis, McGraw Hill 2nd edition 1986.
5. Srinivas J. & Rao Dnkkipati, A textbook of Mechanical Vibration, Prentice Hall of India Pvt. Ltd. New Delhi 2nd Edition 2012.

Reference Books:

1. Srinivasan P. ,Non Linear Mechanical Vibration, New Age Publishers 2017
2. Thomas William ,Theory of Vibration with Application, PHI 5thedition 1997

Subject Code: MME-113 **Subject Name: Mechatronics**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:1**0-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Core

Prerequisites: NA

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Understand key elements of mechatronics system.
2.	Select and use appropriate Sensors & Transducers for automated solutions.
3.	Design and implements digital logics using various gates for industrial applications.
4.	Understand the architecture and operation of typical microprocessors and microcontrollers.
5.	Program and automated solutions using PLC.

Detailed Contents:

1. **Introduction:** Integration of mechanical, electronics, control and computer science engineering, Elements of mechatronics system, Open-loop and closed-loop system. **6Hrs**
2. **Sensors & Transducers:** Sensors and Transducers, Performance Terminology, Displacement, Selection of Sensors, Displacement, Position and Proximity sensors, Flow sensors, Pressure and force sensors, Motion sensors, Optical, Mechanical and Thermal sensors. **6Hrs**
3. **Actuators:** Actuation Systems- Mechanical, Hydraulic, Pneumatic and Electrical, A. C. Motor, D.C. Motor, Stepper Motor. Design of pneumatic logic circuits. **4Hrs**
4. **Electronic Fundamentals:** Signal conditioning, Operational amplifier, Digital logic, Logic gates, Boolean algebra, Data acquisition systems, Measurement systems, Testing and calibration. **8Hrs**
5. **Microprocessor & Computer:** Computer and Interfacing, AD and DA converters, Microcomputer structure, Microcontrollers, Application of Microcontrollers. Programmable logic controller, Basic PLC structure, Input/output processing, Ladder programming. **6Hrs**
6. **Design & Mechatronics:** Designing, Possible design solutions, Case Studies of Mechatronic systems. **6Hrs**

Text Books:

1. W. Bolton, "Mechatronics", 4th Edition, Pearson Education, 2011.
2. Alciatore David G, Histand Michael B, "Introduction to Mechatronics and Measurement Systems", 4th Edition, Tata McGraw Hill, 2006.
3. S.R. Majumdar, "Pneumatic Control", 4th Edition, Tata McGraw Hill, 2004.
4. Musa Jouaneh, " Fundamentals of Mechatronics", 1st Edition, Cengage Learning, 2012.
5. Devdas Shetty, Richard A. Kolk, "Mechatronics System Design", 2nd Edition, Cengage Learning, 2011.

Reference Books:

1. D.M. Auslander, C.J. Kempf, "Mechatronics: Mechanical System Interfacing", 1st Edition, Prentice Hall Inc., 1996.

2. Brian Morriss, “Automated Manufacturing Systems – Actuators, Controls, 1st Edition, Sensors and Robotics”, McGraw Hill, 2000.

Subject Code: MME-114 **Subject Name: Dynamics of Rotating Machines**

Programme: M.Tech (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 50-60
External Marks: 100	**Duration of End Semester Exam (ESE):** 03hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Able to balance the rotating masses.
2.	Analyze the dynamic and vibration characteristics of mechanical systems.
3.	Solve a range of engineering applications, including gyroscopic sensors, bearings, shafts and other rotating machinery.
4.	Apply advance analytical techniques in balancing the rotating machines.
5.	Able to monitor and diagnose the faults in rotating machines.

Detailed Contents:

1. **Modelling and Bending Critical Speeds of Rotors**: Whirling Phenomenon, Rigid rotors in rigid supports, Flexible rotors in rigid supports, Flexible rotors in flexible supports. **4 Hrs**
2. **Bearings:** Rolling Element Bearings, Contact Forces, Deformations, Stiffness and Damping, Hydrodynamic Bearings, Mechanism of Pressure Development in a Fluid Film, Reynold's Equation, and Steady State Solution for Short Bearing, Dynamically loaded bearings and stiffness and damping coefficients, Squeeze Film Bearing, Squeeze Film Bearing and Orbital Motion. **7 Hrs**
3. **Matrix methods:** Field and Point Matrices, Out of balance response of rotors with rigid end supports, Rotors with overhangs, Unbalance response by FEM. **5 Hrs**
4. **Torsional Vibration of Rotors:** Modelling and transfer matrix analysis for free vibrations, Variable Stiffness in Torsional Vibrations, Excitation torques and transient response, Branched and Geared Systems, Torsional vibrations in reciprocating machinery. **5 Hrs**
5. **Higher order effects and Stability:** Hill's Equation, Mathieu's Equation, Strutt Diagram, Routh Hurwitz criterion, Shafts with dissimilar moments of inertia, Effects of Gravity, Internal Hysteresis of Shafts, Rigid Rotor Instability, Instability of rotors mounted in fluid film bearings, Instability of flexible rotors, Instability due to negative cross-coupling, Instability in torsional vibrations, Gyroscopic Effects . **7 Hrs**
6. **Rotor Balancing:** Classification of Rotors, Rigid rotor balancing, Flexible rotor balancing. **4 Hrs**
7. **Monitoring and Diagnosis:** Faults in rotating machinery, Instrumentation and Data Acquisition, Time and Frequency domain Characteristics, Knowledge base and expert systems. **4Hrs**

Text Books:

1. Ehrich(ed.), F.F., *Handbook of Rotordynamics*, McGraw-Hill, 1992.
2. Genta, G., *Vibration of Structures and Machines*, 3rd edition, Springer, 1999.
3. Rao J.S., *Rotor Dynamics*, Third ed., New Age, New Delhi, 1996.
4. Wowk, V., *Machinery Vibration: Balancing*, McGrawHill, 1995.

5. Childs, D, *Turbomachinery Rotor Dynamics: Phenomena, Modeling and Analysis*, John Wiley and sons, 1993.

Reference Books:

1. Genta, G., *Dynamics of Rotating Systems*, Springer, NY, 2005.
2. Vance J.M., *Rotordynamics of Turbomachinery*, John Wiley & Sons, Inc., NY, 1988.

Subject Code: MME-116 Subject Name: Sustainability Designing and Manufacturing

Programme: B.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**NIL
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Additional Material Allowed in ESE: NIL

On completion of the course the student will have the ability to understand:

CO #	Course Outcomes
1.	Concepts of Sustainability and Sustainable Development
2.	Tools and Techniques of Sustainable Manufacturing
3.	EIA Methods
4.	Design for Recycling
5.	Frameworks for Measuring Sustainability

Detailed Contents:

1. **Definition of sustainability** – Need for sustainable development - Components of sustainability- Social, Economic, Environmental dimensions - Linkages between technology and sustainability - Sustainable Manufacturing –Scope, Need, design, practice, matrices and Benefits, Sustainable business models, Waste minimization. **10Hrs**
2. **Concept of sustainable development -** Environmental Conscious Quality Function Deployment, Life cycle management and assessment, Design for Environment, R3 and R6 cycles, Design for Disassembly - Sustainable Product Development – Various Phases. **08Hrs**
3. **Standards:** CML, EI 95 and 99, ISO 14001 EMS and PAS 2050 standards, Environmental Impact parameters - Interactions between energy and technology and their implications for environment and sustainable development **06Hrs**
4. **Eco friendly product design methods:** Methods to infuse sustainability in early product design phases – Multi-Criteria Decision Making in Sustainability. **06Hrs**
5. **Indicators of sustainability –** Environmental, Economic, Societal and Business indicators - Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment– Corporate Social Responsibility. **06Hrs**

Text Books:

1. Sayer, J. and Campbell, B., The Science of Sustainable Development : Local Livelihoods and the Global Environment (Biological Conservation, Restoration &Sustainability), Cambridge University Press, London, 2003.
2. Kirkby, J., O"Keefe, P. and Timberlake, Sustainable Development, Earthscan Publication, London,1993.
3. MoEF (2012), " Sustainable Development in India –stocktaking in the Run up to Rio plus 20", Ministryof environment and forests, Government of India, New Delhi.
4. United Nations. 2001. Indicators of Sustainable Development: Guidelines and Methodologies. New York: United Nations.
5. UNEP, 2011, Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication, www.unep.org/greeneconomy, ISBN: 978-92-807-3143-9

Reference Books:

1. P. Lawn, Sustainable Development Indicators in Ecological Economics, Edward Elgar Publishing Limited.
2. S. Asefa, The Economics of Sustainable Development, W.E. Upjohn Institute for Employment Research

E-Books and online learning material

1. Kaushik Kumar Divya Zindani Paulo Davim, Sustainable Manufacturing and Design, Woodhead Publishing

Online Courses and Video Lectures

2. **https://www.youtube.com/watch?v=8tufBUqwRsg Accessed on 18/11/2021**
3. **https://www.youtube.com/watch?v=rlHrMiuUJS8 Accessed on 18/11/2021**

Subject Code: MME-117 **Subject Name: Vibration and Noise Control**

Programme: M.Tech.(ME)	L: 3 T: 0 P: 0
Semester:2nd / 3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 50-60
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status**: Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Explain fundamentals of noise and vibration in mechanical systems.
2.	Determine natural frequency of mechanical system.
3.	Analyze vibratory response of mechanical system.
4.	Estimate the parameters of Noise and Vibratory System.
5.	Develop mathematical model to represent dynamic system.

Detailed Contents:

1. **Basics of Vibration:** Introduction, classification of vibration: free and forced vibration, undamped and damped vibration, linear and non linear vibration, response of damped and undamped systems under harmonic force, analysis of single degree and two degree of freedom systems, torsional vibration, determination of natural frequencies. **06Hrs**
2. **Undamped Free Vibrations**: Rayleigh's method. Solution of differential equation of motion.
3. Damped Free Vibrations: Viscous damping: coefficient of damping; damping ratio; under damped, over damped and critically damped systems; logarithmic decrement. **06Hrs**
4. **Harmonically excited Vibration**: One degree of freedom- forced harmonic vibration; excitation due to rotating and reciprocating unbalance; vibration Isolation, force and motion transmissibility; absolute and relative motion of mass (Seismic Instruments). **04Hrs**
5. **Systems With Two Degrees of Freedom** : Un-damped free vibration of 2 DOF and Principal modes of vibration; torsion vibrations; Forced, Un-damped vibrations with harmonic excitation ; Dynamic vibration absorber; torsion Vibration Absorber; **04Hrs**
6. **Basics of Noise:** Introduction, amplitude, frequency, wavelength and sound pressure level, addition, subtraction and averaging decibel levels, noise dose level, legislation, measurement and analysis of noise, measurement environment, equipment, frequency analysis, tracking analysis, sound quality analysis. **04Hrs**

   Noise Engineering Subjective response of sound: Frequency and sound dependent human response; the decibel scale; relationship between, sound pressure level (SPL), sound power level and sound intensity scale; relationship between addition, subtraction and averaging, sound spectra and Octave band analysis; loudness; weighting networks; equivalent sound level, auditory effects of noise; hazardous noise, exposure due to machines and equipments; hearing conservation and damage risk criteria, daily noise doze. **06Hrs**
7. **Noise: Sources, Isolation and Control**: Major sources of noise on road and in industries, noise due to construction equipments and domestic appliances, industrial noise control, strategies-noise control at source (with or without sound enclosures), noise control along the path (with or without partitions and acoustic barriers); noise control at the receiver, ear defenders, earplugs, semi-insert protectors. **06Hrs**

Text Books

1. Singiresu S.Rao, “Mechanical Vibrations”, 6th Edition, Pearson Education, 2016.
2. Kewal Pujara “Vibrations and Noise for Engineers, Dhanpat Rai & Sons, 1992.
3. Bernard Challen and Rodica Baranescu - “Diesel Engine Reference Book”, Second Edition,SAE International, 1999
4. David Bies colin Hansen, “Engineering Noise Control – Theory and Practice”,4th E and FN Spon, Taylore & Francise e-Library, 2009
5. Grover. G.T., “Mechanical Vibrations”, Nem Chand and Bros., 2009

Reference Books

1. Balakumar Balachandran and Edward B. Magrab, “Fundamentals of Vibrations”, 1st Editon, Cengage Learning, 2009
2. Benson H. Tongue, “Principles of Vibrations”, 2nd Edition, Oxford University, 2007

Subject Code: MOME-155/MME-118 **Subject Name: Composite Materials**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:1**0-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status: Elective**

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO#	Course Outcomes
1.	Know the advanced and specific applications of composite materials.
2.	Identify various constituents of composite materials and their characteristics.
3.	Suggest and use standard methods for determining mechanical properties of different types of composite materials.
4.	Use various techniques for processing of composite materials.
5.	Understand the suitability of use of composite material in specific industrial application.

Detailed Contents:

1. **Introduction:** History of composite materials, classification of composite materials, properties of composites compared to conventional materials, applications of composites. **4Hrs**
2. **Matrices and Reinforcements:** Introduction to different types of matrices; difference between thermosetting and thermoplastic matrices, chemical structure and characteristic features of polymer matrices, curing system; role of matrix in continuous fibre composites; introduction to different types of reinforcements; characteristic features and role of fibres, particles, whiskers as reinforcing agents. **4Hrs**
3. **Mechanical Properties -Stiffness and Strength:** experimental determination of mechanical properties (compressive, flexural and shear) of composite materials using standard test procedures; failure theories of polymer matrix composites**.** **4Hrs**
4. **Design Concepts of Composite Materials:** Stress distribution in fibre and matrix, rule of mixtures, analysis of uniaxial tensile stress-strain curve of unidirectional continuous and short fibre composites, estimation of minimum and critical amount of reinforcement. **4Hrs**
5. **Manufacturing methods :** hand lay-up, autoclaving, filament winding, pultrusion, compression molding, pre-pegging, sheet molding compounds; primary processing techniques for ceramic and metal matrix composites (CMCs and MMCs); stir and squeeze casting, powder metallurgy, liquid infiltration process Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting and prepregs. **5Hrs**
6. **Processing of Composite Materials:** Processing techniques of polymeric matrix composites (PMCs); process mechanism, capability and application areas of various techniques; Fibre/Matrix Interface, mechanical. Measurement of interface strength. Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc. **5Hrs**
7. **Secondary Processing of Composite Materials**: Machining, welding, adhesive joining and mechanical fastening of composite materials (as relevant and specific for PMCs, CMCs and MMCs). **5Hrs**
8. **Joining Methods and Failure Theories:** Joining –Advantages and disadvantages of adhesive and mechanically fastened joints. Typical bond strengths and test procedures. **5Hrs**

Text Books:

1. Mathews F.L and Rawlings R.D, Composite Materials: Engineering and Science, Woodhead Publishing, ISBN: 9781855734739, 1st Edition, 1999.
2. Hull D. and Clyne T.W., An Introduction to Composite Materials, 2nd Ed., Cambridge University Press, 2013
3. Chawla K.K., Composite Materials: Science and Engineering 3rd Ed., Springer, 2012
4. Chawla K.K., Ceramic Matrix Composites, 2nd Ed., Springer, 2003
5. Chawla N. Chawla K.K., Metal Matrix Composites, 2nd Ed. Springer, 2013

ReferenceBooks: .

1. Shojiro O., Mechanical Properties of Metallic Composites, Marcel Dekker, 2002
2. Deborah D.L. Chung, Composite Materials: Science and Applications, 2nd Ed. Springer, 2010

Online Courses and Video Lectures:

1. **https://nptel.ac.in/courses/112/104/112104229/**
2. **https://nptel.ac.in/courses/112/104/112104168/**
3. **https://nptel.ac.in/courses/101/104/101104010/**
4. **https://nptel.ac.in/courses/112/104/112104221/**
5. **https://nptel.ac.in/courses/112/104/112104249/**

Subject Code: MME-119 Subject Name: Instrumentation and Control Engineering

Programme: M.Tech.	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 20-30
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Elective Status:** Elective

Additional Material Allowed in ESE: NIL

On Completion of the course, the student will have the ability to:

CO	Course Outcomes
1.	Explain various measurement types and elements associated with it.
2.	Apply the concept of static and dynamic characteristics of measuring instruments.
3.	Analyze various forms of measurement.
4.	Use of instruments for linear, angular, stress and strain.
5.	Analyze various control systems.

Detailed Contents:

1. **Measurement & Measurement Systems:** Methods of measurement, Mechanical, Electrical & Electronic Instruments, and Deflection & Null type Instruments, Elements of Measurement System, Input- Output Configuration of Measuring Instruments and Measuring Instruments. **5Hrs**
2. **Static & Dynamic Characteristics of Instruments and Measurement System:** Static Correction, Scale range and scale span, Errors & Calibration, Accuracy & Precision, Sensitivity of Instruments, Linearity, Hysteresis and Threshold. First & Second order System and their response to step, ramp input. **6Hrs**
3. **Metrology:** Standards, Comparators, Linear & Angular Measurement, Measurement of Geometric Shapes, Interferometer, Measurement of Screw Threads and Gears, Surface Texture. **6Hrs**
4. **Stress and Strain Measurement:** Ballast Circuit, Wheatstone Bridges, Gauge Sensitivity, Interpretation of Results, Strain Gauge calibration, Stress – Strain Relationship, Rosettes, Strain Gauge Circuitry. **6Hrs**
5. **Digital Techniques in Mechanical Measurement:** Fundamental digital circuit elements, Combination of logic elements, IC families, IC Oscillators and clock signals. Digital Displays, Number Systems, Binary Codes, Computer as a measurement system. **6Hrs**
6. **Control Systems:** Introduction, Functioning, Elements of control systems, Classification and types of control system , Examples of feedback control systems and their block diagrams, transfer function of element, system and processes, transient and steady state response of control systems, stability of control systems. **7Hrs**

Text Books:

1. E.O. Doelbin " Measurement Systems: Application and Design" McGraw- Hill.
2. A.K. Sawhney ,"Mechanical Measurement & Metrology", Dhanpat Rai & Co.
3. S.P. Venkateshan , "Mechanical Measurements", Ane Books Pvt. Ltd.
4. T.G. Beckwith, R.D. Marangoni and J.H. Lienhard V, Mechanical Measurements", Pearson.
5. R.K. Rajput, "Mechanical Measurement & Instrumentation", Katson.

Subject Code: MME-122 **Subject Name: Design of Steam turbine**

Programme: B.Tech.	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 30-40
External Marks: 100	**Duration of End Semester Exam (ESE):** 3hours
Total Marks: 150	**Elective Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On Completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Recognize various types of steam turbine.
2.	Analyze flow of steam through a turbine.
3.	Design of nozzle and blade dimensions.
4.	Apply basic law to determine various losses in steam turbine.
5.	Design of single pass and multi pass steam turbine.

Detailed Contents:

1. **Introduction:** Fundamentals of principles of turbine design and short introduction of their development. Development of the turbine building industry, Classification of steam turbine, principle of action of a steam turbine. **4Hrs**

2. **Flow of steam through a turbine stage:** Expansion of steam in nozzles – neglecting losses, Expansion of steam in nozzles – considering losses, Expansion of steam in nozzles at conditions other than designed, Expansion of steam in oblique region of nozzles, transformation of energy in the moving blade of an impulse turbine, transformation of energy in the moving blade of an reaction turbine **5Hrs**

3. **Determination of nozzle and blade dimensions:** Determination of nozzle size, determination of the height of moving blade. **6Hrs**

4. **Energy losses in steam turbine:** Classifications of turbine losses, Losses in regulating valve, losses in nozzles, losses in moving blade, leaving velocity (carry over) losses, losses due to disc friction and windage, clearance losses, losses due to wetness of steam, exhaust piping losses, external losses, efficiency of turbine, determination of mass flow of turbine. **6Hrs**

5. **Single stage turbine:** Single stage impulse turbine with one velocity stage, design of single stage impulse turbine (sequences of calculations), single stage impulse turbine with two velocity stages, sequences of calculations for design of single stage impulse turbine with two velocity stages, Design of two row impulse turbine. **5Hrs**

6. **Multistage turbine:** Impulse turbine with pressure stages, heat drop process for multistage turbine, heat recovery coefficients, characteristic coefficients for multistage turbine, reaction in pressure stages, heat drop calculations for multistage turbine, design procedure for multistage impulse turbine, reaction turbine, efficiency of reaction turbine, distribution of heat drop in the reaction turbine, calculation of axial thrust, Heat calculation for turbine type K-50-90(KV-50). **5Hrs**

7. **Construction of turbine rotors and their components:** Materials and construction of moving blade, design of blade, vibration of blades, causes of blade vibrations, design and construction of rotors, rotors of impulse turbine, design of turbine shafts, critical speed of rotors, design of shaft with two supports. **5Hrs**

Text Books:

1. Steam Turbine – theory and design by P. Shlyakhin Foreign Languages Publishing House, Moscow.
2. Steam Turbine – Theory and Practice by William J. Kearton. CBS Publishers & Distributors Pvt. Ltd.
3. Steam Turbine and their cycles by J. Kenneth Salisbury. John Wiley & Sons. New York.
4. Leyzerovich, Alexander (2005). Wet-steam Turbines for Nuclear Power Plants. Penn Well Books.
5. Parsons, Charles A (1911). The Steam Turbine . Cambridge University Press.

Reference Books:

1. Thurston, RH (1878). A History of the Growth of the Steam Engine. New York: D Appleton and Co.
2. Johnston, Ian (2019). "The Rise of the Brown-Curtis Turbine". In Jordan, John (ed.). Warship 2019. Oxford: Osprey Publishing. pp. 58–68.

Subject Code: MME-123 **Subject Name:** Convective Heat Transfer

Programme: M.Tech(ME).	**L:** 3 **T:** 0 **P:** 0
Semester: 2^{nd} /3^{rd}	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 50-60
External Marks: 100	**Duration of End Semester Exam (ESE):** 03hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Fundamentals of heat transfer

Additional Material Allowed in ESE: Databook

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Understand and apply governing equations in convection heat transfer.
2.	Execute different methods to calculate heat transfer for laminar Internal and external flows in different conditions.
3.	Understand the governing equation and calculate heat transfer by natural convection.
4.	Apply different analogies to measure heat transfer in turbulent conditions due to convection.
5.	Develop different mathematical models related to heat transfer in turbulent conditions on different geometries.

Detailed Contents:

1. **Governing Equations**: Continuity, Momentum and Energy Equations and their derivations in different coordinate systems, Boundary layer Approximations to momentum and energy. **4 Hrs**
2. **Laminar External Flow and Heat Transfer**: (a) Similarity solutions for flat plate (Blasius solution), flows with pressure gradient (FalknerSkan and Eckert solutions), and flow with transpiration, (b) Integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature (Duhamel's method), flows with pressure gradient (von Karman-Pohlhausen method). **8Hrs**
3. **Laminar Internal Flow and Heat Transfer:** (a) Exact solutions to N-S equations for flow through channels and circular pipe, Fully developed forced convection in pipes with different wall boundary conditions, Forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, (b) Integral method for internal flows with different wall boundary conditions **8Hrs**
4. **Natural Convection Heat Transfer:** Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical plate with constant wall temperature and heat flux conditions, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures. **8 Hrs**
5. **Turbulent Convection:** Governing equations for averaged turbulent flow field (RANS), Analogies between heat and Mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies), Turbulence Models (Zero, one and two equation models), Turbulent flow and heat transfer across flat plate and circular tube, Turbulent natural convection heat transfer, Empirical correlations for different configurations. **8 Hrs**

Text Books:

1. A. Bejan, *Convection Heat Transfer*, Wiley India, 2013.
2. K. Sadik, and Y. Yaman, *Convection Heat Transfer,* CRC press, 1995.
3. W. Kays and.M. Crawford, *Convective Heat and Mass Transfer*, McGraw Hill, 2005.
4. Cebeci, Tuncer. *Convective heat transfer*. Berlin: Horizons Pub., 2002.
5. Cebeci, Tuncer, and Peter Bradshaw. *Physical and computational aspects of convective heat transfer*. Springer Science & Business Media, 2012.

Reference Books:

1. Frank P. Incropera and David P. Dewitt, *Fundamental of Heat and Mass Transfer*, Wiley India, 2002.
2. H. Schlichting and K. Gersten.Q, *Boundary Layer Theory*, Springer-Verlag, 2000

Subject Code: MME-125 Subject Name: Conductive and Radiative Heat Transfer

Programme: M.Tech(ME).	**L:** 3 **T:** 0 **P:** 0
Semester: 2^{nd} /3^{rd}	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 50-60
External Marks: 100	**Duration of End Semester Exam (ESE):** 03hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Fundamentals of heat transfer

Additional Material Allowed in ESE: Databook

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Understand the fundamentals of conduction and radiation heat transfer.
2.	Apply analytical techniques to solve 2-D and 3-D conduction problems.
3.	Analyze complex practical problems using principles of conduction and radiation heat transfer.
4.	Estimate radiative properties and analyze gray, non-gray, diffuse-gray and nondiffuse surfaces.
5.	Understand the concepts and solve problems of radiation heat transfer in participating medium.

Detailed Contents:

1. **Recapitulation of conduction heat transfer**: Introduction to Conduction- Recapitulation: Steady and Transient conduction; Fins, Lumped parameter and semi-infinite solid approximations, Heisler and Grober charts; 3-D conduction, isotropic, orthotropic and anisotropic solids. **6 Hrs**
2. **Analytical Methods:** Analytical Methods- Mathematical formulations, analytical solutions, variation of parameters, integral method, periodic boundary conditions, Duhamels theorem and Greens function. **8 Hrs**
3. **Applications to practical problems:** Stationary and moving heat sources and sinks. Moving boundary problems. Inverse heat conduction problems, freeze drying problems.
   Stationary and moving heat sources and sinks. Moving boundary problems. Inverse heat conduction problems, freeze drying problems. **5 Hrs**
4. **Recapitulation of Radiation:** Introduction to Radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Planck's law, Wien's displacement law, Black and Gray surfaces, Emissivity, absorptivity, Spectral and directional variations, View factors. **4Hrs**
5. **Transparent, diffuse, gray surfaces:** Enclosure with Transparent Medium- Enclosure analysis for diffuse-gray surfaces and non-diffuse, no-gray surfaces, net radiation method. **6 Hrs**
6. **Radiation in participating Medium:** Enclosure with Participating Medium- Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation. **7 Hrs**

Text Books:

1. D W Hahn, and M N Ozisik, *Heat Conduction*, John Wiley & Sons, 3rd Edition, 2012.
2. M F Modest, *Radiative Heat Transfer*, Academic Press, 3rd Edition, 2013.

3. J R Howell, M P Menguc, and R Siegel, *Thermal Radiation Heat Transfer*, CRC Press, 6th Edition, 2015.
4. Cebeci, Tuncer. *Convective heat transfer*. Berlin: Horizons Pub., 2002.
5. Cebeci, Tuncer, and Peter Bradshaw. *Physical and computational aspects of convective heat transfer*. Springer Science & Business Media, 2012.

Reference Books:

1. Frank P. Incropera and David P. Dewitt, *Fundamental of Heat and Mass Transfer*, Wiley India, 2002.
2. V S Arpaci, *Conduction Heat Transfer*, Addison-Wesley, Reading, MA, 1966.

Subject Code: MME-127 **Subject Name: Design of HVAC Systems**

Program: B.Tech.(ME**)**	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours: 36**
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 10-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Course Status:** Elective

Prerequisites:

Additional Material Allowed in ESE: [Scientific Calculator]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Analyse the heat load and mechanical ventilation.
2	Evaluate the heat losses due to various methods.
3	Design HVAC systems.
4	Design piping and air ducts.
5	Design the equipments for the HVAC systems.

Detailed Contents:

1. **Heating design load calculation:** Heating load calculations, natural and mechanical ventilation, user profiles and operation schedules, occupant comfort and health. **10 Hrs**
2. **Energy Balance of a Building:** Preparation of the energy balance of a building, heat losses due to transmission and ventilation, effects of solar radiation, heat gains, HVAC systems efficiency, basics of energy performance evaluation and certification. **12 Hrs**
3. **Design of HVAC Systems:** Design of heating, cooling, ventilating and air conditioning systems: hydronics, all air and mixed air/water systems. Distribution network (piping and air ducts) terminal units. Heat recovery equipment **08 Hrs**
4. **Equipments for HVAC Systems**: Equipment for heating and cooling: boilers, unitary air conditioners, water chillers storage tanks, circulation pumps. Renewable energy equipment: thermal solar panels and heat pumps. Equipment operating curves and partial load operation. Safety devices and introduction to safety standards. **06Hrs**

Text Books

1. C.P. Arora, *"Refrigeration and Air Conditioning"*, Tata McGraw Hill, 3rd Edition, 2009.
2. S.C. Arora, S. Domkundwar and V.A. Domkundwar, *"A Course in Refrigeration and Air Conditioning",* Dhanpat Rai & Co (P) Ltd., Reprint, 2015.
3. M. Prasad, *"Refrigeration and Air Conditioning"*, New Age International (P) Ltd. Publishers, 3rd Edition, 2015.
4. R.C. Jordan and G.B. Priester,, *"Refrigeration and Air Conditioning"*, Prentice Hall of India, 2nd Edition, 1956.
5. W.F. Stoecker, *"Refrigeration and Air Conditioning"*, McGraw Hill, 2nd Edition, 1983**.**

Reference Books:

1. Modern Refrigeration and Air Conditioning by Andrew D. Althouse
2. Haines, Roger W., and Michael E. Myers. *HVAC systems design handbook*. McGraw-Hill Education, 2010.

Subject Code: MME-128 Subject Name: Design and Optimization of Thermal Systems

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems:**50%
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Core

Prerequisites: Thermodynamics and Heat Transfer

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Explain the basic concepts of optimization and its use as a tool for decision making
2.	Apply various optimization methods to thermal engineering problems based on linear programming, non-linear programming and stochastic programming,
3.	Simulate engineering problems which are interdisciplinary in nature using unconventional optimization techniques
4.	Apply optimization procedures and design optimized thermal systems.
5.	Understand some of the ethical and societal issues associated with decision making and will be aware of recent developments in area of thermal systems

Detailed Contents:

1. **Introduction**: Introduction to design and specifically system design, Importance of Modeling in Design, Morphology of design with a flow chart, market analysis, profit, time value of money, Concept of workable design, Optimization, Analysis and Design, Workable system and Optimum system, Thermal Systems and their basic characteristics. **04 Hrs**
2. **Modeling of Thermal Systems:** Importance of Modeling in Design, Basic Features of Modeling, Types of Models: Analog Models, Mathematical Models, Physical Models, Numerical Models, Interaction between Models, Mathematical Modeling: General Procedure, Final Model and Validation, Dimensional Analysis Modeling and Similitude Overall Physical Model, Numerical Modeling: General Features Development of a Numerical Model, Available Software, Solution Procedures: Algebraic Systems, Nonlinear Algebraic Systems, Ordinary Differential Equations, Partial Differential Equations, Numerical Model for a System: Modeling of Individual Components, Merging of Different Models, Accuracy and Validation System. **06Hrs**
3. **Simulation:** Importance of Simulation, Different Classes, Flow of Information, Methods for Numerical Simulation: Steady Lumped Systems, Dynamic Simulation of Lumped Systems, Distributed Systems, Simulation of Large Systems, Numerical Simulation Versus Real System. **04 Hrs**
4. Design of Systems from Different Application Areas: Manufacturing Processes, Cooling of Electronic Equipment, Environmental Systems, Heat Transfer Equipment, Fluid Flow Systems and Other Areas. **06 Hrs**
5. **Problem Formulation for Optimization:** Optimization in Design, Final Optimized Design, Objective Function, Constraints, Operating Conditions Versus Hardware, Mathematical Formulation, Optimization Methods: Calculus Methods, Search Methods, Linear and Dynamic Programming, Geometric Programming, Other Methods, Optimization

of Thermal Systems: Important Considerations, Different Approaches, Different Types of Thermal Systems Examples, Consideration of the Second Law of Thermodynamics, Practical Aspects in Optimal Design, Choice of Variables for Optimization, Sensitivity Analysis, Dependence on Objective Function: Trade-Offs, Multi-Objective Optimization, Part of Overall Design Strategy, Change of Concept or Model . **08 Hrs**

6. **Non-traditional Optmization Techniques:** Geometric Programming: Applicability, Unconstrained Optimization, Mathematical Proof Constrained Optimization, Nonzero Degree of Difficulty, Genetic Algorithm (GA) - basics features, principle and robustness of GA, Particle swarm optimization, Simulated Annealing, Artificial Neural Networks.**08 Hrs**

Text Books:

1. 1. C Balaji, Essentials of Thermal System Design and Optimization, Ane Books Pvt Ltd.
2. S S Rao, Optimization Theory and Applications, Wiley Eastern
3. S S Sastry, Introductory Methods of Numerical Analysis, Prentice Hall
4. P. Meier, Energy Systems Analysis for Developing Countries, Springer Verlag
5. Jaluria, Yogesh. Design and optimization of thermal systems. CRC press, 2007.

Reference Books:

1. W.F. Stoecker, Design of Thermal Systems, McGraw Hill
2. Yogesh Jaluria, Design and Optimization of Thermal Systems – Second Edition, CRC Press

Subject Code: MME-129 **Subject Name:** Advanced Heat and Mass Transfer

Programme: M.Tech(ME).	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 50
External Marks: 100	**Duration of End Semester Exam (ESE):** 03hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Fundamentals of heat and mass transfer

Additional Material Allowed in ESE: Databook

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Apply the general conduction equations using the boundary conditions
2.	Implement the conduction equation in optimization of fins and multidimensional heat flow
3.	Analyze and calculate different parameters related to free and forced convection.
4.	Understanding the Nano fluids and their applications
5.	Understand different types of boiling and condensation phenomenon and apply their mathematical relations in numerical.

Detailed Contents:

1. **Conduction**: General conduction equations, boundary & initial conditions, radial fins & fin optimization, multidimensional heat conduction, transient heat conduction. **10 Hrs**
2. **Convection**: Forced convection, velocity and thermal boundary layers, laminar and turbulent flow, boundary layer approximations, convection transfer equations, dimensionless parameters, empirical correlations, free convection, empirical correlations for external free convection flows for various geometries and orientations, heat pipes, Nano fluids and their applications. **10 Hrs**
3. **Boiling and Condensation:** Pool boiling, correlations, forced convection boiling, two phase flow, laminar film condensation on a vertical plate, turbulent film condensation, film condensation in horizontal tubes, drop wise condensation correlations **6 Hrs**
4. **Thermal Radiation:**
   Thermal radiations and associated laws, radiation exchange between surfaces, view factor, network method, reradiating surfaces. Multimode heat transfer, gaseous emission and absorption. **10Hrs**

Text Books:

1. A. Yunus Cengel, *Heat and Mass transfer*, McGraw Hill Education private limited, 4th Edition, 2013.
2. A. J., Chapman, *Heat transfer*, McGraw Hill, 7th Edition, 1997.
3. P. K, Nag, *Heat transfer*, McGraw Hill, 7th Edition, 1997
4. D. S. Kumar, *Fundamentals of Heat and Mass Transfer*, S K Kataria & Sons, 7th Edition, 2013.
5. M.Q. Brewster, *Thermal Radiative Transfer and Properties,* John Wiley, 2006

Reference Books:

1. Frank P. Incropera and David P. Dewitt, *Fundamental of Heat and Mass Transfer*, Wiley India, 2002.
2. A. Bejan, *Convection Heat Transfer*, Wiley India, 2003.

Online Courses and Video Lectures

1. https://nptel.ac.in/courses/103/105/103105052/ Accessed in Nov 2021

Subject Code: MME-131 **Subject Name: Advanced Welding Technology**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems: 0** %
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Fundamentals of welding

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Apply the principles of welding processes and develop analytical relation between input and output process parameters
2.	Analyze and apply the concept of metal transfer and power sources in welding
3.	Apply the fundamentals of physics to develop theoretical concepts for different types of welding processes
4.	Understand and analyze the concepts of solid state welding
5.	Apply the concepts of testing of weldment.

Detailed Contents:

1. **Introduction:** Welding– Definition, industrial importance, applications; advantages of welding over other fabrication processes; classification of welding and allied processes, weldability, weld thermal cycle, metallurgy of fusion welds, solidification mechanism and micro-structural changes in weld metal, metallurgical changes in weld metal, phase transformation during cooling of weld metal in carbon and low alloy steel, prediction of microstructures and properties of weld metal, heat affected zone (HAZ), re-crystallization and grain growth of HAZ, gas metal reaction. **6 Hrs**
2. **Fundamentals of Arc Welding & Power Sources:** Arc characteristics, arc physics, arc plasma, arc structure, arc stability, arc efficiency; brief introduction to bead geometry and melting rate, mode of metal transfer- short circuit, globular and spray mode of transfer, various factors and forces affecting metal transfer; welding power sources- introduction to transformers, rectifiers and inverters; power source characteristics- static and dynamic volt-ampere characteristics, duty cycle; arc blow- causes and its control. **6 Hrs**
3. **Fusion welding :** Manual metal arc welding (MMAW), Gas tungsten arc welding (GTAW), Gas metal arc welding (GMAW), Flux-cored arc welding (FCAW) and CO welding processes, Plasma arc, Submerged arc welding, Electro gas and Electro slag welding. **6 Hrs**
4. **Resistance Welding:** Basic principle; Spot, Seam, Projection and Flash butt welding; welding variables; heat shrinkage, heat balance; process capabilities and applications. Stud welding, basic principle & applications. **6Hrs**
5. **Solid State welding:** Theory and mechanism of solid state welding, techniques and scope of Friction welding, Friction stir welding, Diffusion welding, Cold pressure welding and Ultrasonic welding, High energy rate welding, analysis of the process. **6 Hrs**
6. **Testing of weldments:** Visual inspection, Radiography, Magnetic particle inspection, Liquid dye penetrant test, Ultrasonic testing. **6 Hrs**

Text Books:

1.Dr. R.S.Parmar, Welding processes & technology, Khanna Publishers
2.Dr. R.S.Parmar, Welding Engineering & Technology, Khanna Publishers

3.S.V. Nandkarni, Modern Arc Welding Technology, Oxford & IDH publishing Co.
4.L.M. Gourd ELBS/ Edward Arnold, Principles of Welding Technology
5.Koenigsberger and Adaer Welding Technology; Macmillan.

References Books:

1.Lancster; George, the Metallurgy of welding, Allen & Unwin Ltd. U.K.
2.Richard L. Little, Welding & Welding Technology, McGraw Hill

Subject Code: MME-134 **Subject Name: Rapid Prototying**

Programme:B.Tech. (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems: Nil**
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Status:**

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#.	Course Outcomes (Cos)
1	Understand the concept of Rapid prototyping and its importance in today's industry
2	Classify various rapid prototyping techniques based upon their principles and processes.
3	Explain different errors in rapid prototyping to improve the overall working of manufacturing.
4	Discuss various case studies of rapid prototyping in different fields of manufacturing.
5	Illustrate implementation of rapid prototyping in biomedical field.

Detailed Contents:

1. **Introduction:** Introduction to Prototyping, history of RP systems, Growth of RP industry, Traditional Prototyping Vs. Rapid Prototyping (RP), Fundamentals of rapid prototyping, Advantages and limitations of rapid prototyping, Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative, Generic RP process. **6Hrs**
2. **CAD Modeling and Data Processing for RP:** Fundamental Automated Processes, Process Chain, 3D Modeling, Data Conversion and Transmission, Checking and Preparing, Building, Postprocessing, supported file formats for RP (STL, IGES, HP/GL, CT, STEP) **5Hrs**
3. **Errors in RP processes:** Pre-processing, processing, post-processing errors, Part building errors in SLA, SLS. **4Hrs**
4. **RP Processes:** Introduction, Principle, Process, Applications, Mateirals, Advantages and Disadvantages of various RP systems: StereoLithography (STL), Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Selective laser Sintering (SLS) Process, Laser Engineered Net Shaping (LENS), Direct Metal Deposition (DMD), 3D Printing (3DP). **10Hrs**
5. **Case Studies:** Discussion of case studies for various RP manufacturing technologies. **6Hrs**
6. **Biomedical Applications:** Bronchial Stunting, Cranial Implants, Spinal guides, Pedicle screws. **5Hrs**

Text Books:

1. Chua C K, Leong K F, Chu S L, Rapid Prototyping: Principles and Applications in Manufacturing, World Scientific.
2. Gibson D W Rosen, Brent Stucker., Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Springer.
3. Connell, John, and Linda I. Shafer. *Object-oriented rapid prototyping*. Yourdon Press, 1995.

4. Hoque, Md Enamul, ed. *Advanced applications of rapid prototyping technology in modern engineering*. BoD–Books on Demand, 2011.
5. Hoque, Md Enamul, ed. *Rapid prototyping technology: principles and functional requirements*. BoD–Books on Demand, 2011.

Additional Books:

1. Noorani R, Rapid Prototyping: Principles and Applications in Manufacturing, John Wiley & Sons
2. Kamrani A K, Nasr E A, Rapid Prototyping: Theory and practice, Springer,

Subject Code: MME-135 **Subject Name: Advanced Metal Cutting**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2/3	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design/Programming Problems: Nil**
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Design tool geometry of the basic cutting tools like single point cutting tool, drills etc.
2.	Solve the problems related with the measurement of cutting forces, tool wear and should be able to deal with various parameters effectively.
3.	Measure and improve tool life of various cutting tools.
4.	Simulate various machining processes and apply economics of machining.
5.	Understand the different types of defects, causes and apply their remedial measures in metal cutting processes.

Detailed Contents:

1. **Introduction to Metal Cutting:** Introduction, system of Tool nomenclature, Tool Geometry, Mechanism of Chip, formation and forces in orthogonal cutting, Merchant's force diagram. **8Hrs**
2. **Oblique Cutting:** Normal chip reduction coefficient under oblique cutting, true shear angle, effective rake, influx region consideration for deformation, direction of maximum elongation, effect of cutting variables on chip reduction coefficient, forces system in oblique cutting, effect of wearland on force system, force system in milling, effect of helix angle. **6 Hrs**
3. **Fundamentals of Dynamometry:** Theoretical determination of forces, angle relations, heat and temperature during metal cutting; distribution, measurement, analysis, theoretical estimation of workpiece temperature, hot machining. **6 Hrs**
4. **Fundamental factors which effect tool forces:** Correlation of standard mechanised test. (Abuladze – relation), nature of contact and stagnant phenomenon, rates of strains, shear strain and normal strain distributions, cutting variables on cutting forces. **6Hrs**
5. **Cutting Tools:** Tools materials analysis of plastic failure (from stability criterion), Analysis failure by brittle fracture, wear of cutting tools, criterion, flank and crater wear analysis, optimum tool life, tool life equations, (Taylor's woxen etc) Tool life test, machining optimization, predominant types of wear; abrasive, adhesive, diffusion wear models, wear measurements and techniques, theory of tool wear oxidative mathematical modelling for wear. **6 Hrs**
6. **Economics of metal machining:** Machinability, test of machinability and influence of metallurgy on machinability. Economics of metal machining. **4 Hrs**

Text Books:

1. Sen & Bhattacharya, "Principles of Machine tools", New Central Book Agency.
2. Brown, "Machining of Metals", Prentice hall.
3. Shaw, "Principles of Metal cutting", Oxford I.B.H.

4. Arshimov & Alekree, “Metal cutting theory & Cutting tool design”, MIR Publications.
5. Stephenson, David A., and John S. Agapiou. Metal cutting theory and practice. CRC press, 2018.

Subject Code: MME-136 **Subject Name: Advanced Casting Processes**

Programme: B.Tech(ME)	**L**: 3 **T**: 0 **P**: 0
Semester: 2nd /3rd	**Teaching Hours**: 36
Theory/Practical: Theory	**Credits**: 3
Internal marks: 50	**Percentage of Numerical/Design Problems**: 10-20
External marks: 100	**Duration of End Semester Exam**: 3hrs
Total Marks: 150	**Course Status**: Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On Completion of this course, students will have the ability to:

CO#	Course Outcomes
1	Apply the principles of metal casting processes and develop analytical relation between input and output process parameters.
2	Analyze and apply the concept of cooling rate of materials in metal casting.
3	Apply theoretical and experimental techniques for measurement of important outcomes of casting processes like hardness, dimensional accuracy etc.
4	Understand the model of casting economics and optimization and its measurement.
5	Apply the fundamentals of physics to develop theoretical relations for different types of casting processes.

Detailed Contents:

1. **Trends & scope in foundry Industry**: Position of foundry industry worldwide and in India, analysis of data in respect of production and demand, recent trends in quality specifications like dimensional accuracy, surface finish and property requirements, specifications, properties and applications of modern cast alloys- SG iron. Al – alloys, Mo- alloys, Ti – alloys. **6 Hrs**
2. **Design considerations in manufacturing of patterns and dies**: Computer Aided pattern design and manufacture, pattern making machines and equipments, Computer aided design of dies in die casting and centrifugal casting, materials used and allowances in patterns and dies. **7 Hrs**
3. **Design of gating system**: Elements and types of gating systems, , Risers – types and functions of risers, directional solidification – factor affecting, Nucleation kinetics, fundamentals of growth, solidification of single-phase alloys and significance, use of exothermic sleeves, bricks, chills and their types, types and uses of filters, computer aided design for gating and risering systems. **7Hrs**
4. **Advanced molding and core making processes and equipments**: Various types of sands used for molding and core making, testing of sand, high pressure line molding, Dissamatic, chemically bonded sands; shell molding binder, hardener and type of sand used in shell molding, procedure used for making shell sand, plants used, properties and tests on shell sand, stick point strength, advantages and applications; Resin bonded sands, alkyl resins, phenolic resins and furnace sands, cold box method of core making – advantages and applications, ceramic molding, vacuum molding. **5 Hrs**
5. **Special Casting processes**: Investments casting processes and applications; Continuous casting, principle, processes and applications; Die casting, low pressure / gravity, pressure and squeeze, advantages, limitations and applications, centrifugal casting, calculations of various parameters in centrifugal casting, die temperature, rotational speeds, advantages, limitations and applications of centrifugal casting, defects in centrifugal casting. **6Hrs**

6. **Mechanization in Foundries**: Conveying systems – sand bins, belt conveyors, roller conveyors, bucket elevators; Pouring systems – monorail, auto pour systems; sand plants, practical aspects, layout and mechanization . **5 Hrs**

Text Books:

1) Principles of Metal Castings - Heine, Loper and Rosenthal (TMH)

2) Principles of Foundry Technology - P.L. Jain (TMH)

4) Advanced Pattern Making – Cox I.I. (The Technical Press, London.)

5) Metal Castings – Principles & Practice - T.V. Ramana Rao. (New Age International Pvt. Ltd. Publishers.)

Reference Books:

1) Mechanization of Foundry Shops – Machine Construction - P.N. Aeksenov (MIR)

2) Fundamentals of Metal Casting Technology - P.C. Mukherjee (Oxford, IBH)

Subject Code: MME-137 Subject Name: Maintenance and Reliability Engineering

Programme: M.Tech.	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems: 20-30**
External Marks: 100	**Duration of End Semester Exam (ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: NIL

Additional Material Allowed in ESE: NIL

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Understand the principles, functions and practices adapted in industry for the successful management of maintenance activities
2.	Analyze the different maintenance categories like Preventive maintenance, condition monitoring, and repair of machine elements.
3.	Implementation of human reliability and its tools.
4.	Illustrate some of the simple instruments used for condition monitoring in industry.
5.	Identify of human reliability and its tools.

Detailed Contents:

1. **Principles And Practices Of Maintenance Planning:** Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Maintenance organization – Maintenance economics **.6 Hrs**
2. **Maintenance Policies – Preventive Maintenance:** Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle - Principles and methods of lubrication – TPM. 4 **Hrs**
3. **Condition Monitoring** : Condition Monitoring – Cost comparison with and without CM – On-load testing and off-load testing – Methods and instruments for CM – Temperature sensitive tapes – Pistol thermometers – wear-debris analysis **8 Hrs**
4. **Repair Methods For Basic Machine Elements:** Repair methods for beds, slideways, spindles, gears, lead screws and bearings – Failure analysis – Failures and their development – Logical fault location methods – Sequential fault location. **5 Hrs**
5. **Repair Methods For Material Handling Equipment:** Introduction to deterministic and probabilistic dynamic programming. The solution to simple problems. **3Hrs**
6. **Human Reliability And Evaluation Tools**: Need for reliability, Bathtub Hazare rate concept, general reliability analysis formulas, reliability networks, reliability allocations, Failure modes and effect analysis (FMEA), Network reduction method, Decomposition method, Delta star method, Markov method, Supplementary Variables Method, Problems **10 Hrs**

Text Books:

1. Srivastava S.K., "Industrial Maintenance Management", - S. Chand and Co., 1981
2. Bhattacharya S.N., "Installation, Servicing and Maintenance", S. Chand and Co., 1995

3. B. S. Dhillon, Maintainability, Maintenance, and Reliability for Engineers, Taylor and Francis, 2006.
4. Davies, “Handbook of Condition Monitoring”, Chapman &Hall, 1996
5. “Advances in Plant Engineering and Management”, Seminar Proceedings - IIPE, 1996

Reference Books:

1. White E.N., “Maintenance Planning”, I Documentation, Gower Press, 1979.
2. Garg M.R., “Industrial Maintenance”, S. Chand & Co., 1986..

Subject Code: MME-138 **Subject Name: Jig, Fixture and die design**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:**40-50
External Marks: 100	**Duration of End Semester Exam (ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Design Jigs and Fixtures.
2.	To know the types of Jigs & Fixtures.
3.	Design dies in relation to machine.
4.	Purpose of work-piece location, and importance of fool proofing.
5.	Evaluate the applications and failures could occur in Industry.

Detailed Contents:

1. **Purpose Types And Functions Of Jigs And Fixtures:** Tool design objectives - Production devices - Inspection devices - Materials used in Jigs and Fixtures - Types of Jigs - Types of Fixtures-Mechanical actuation-pneumatic and hydraulic actuation-Analysis of clamping force-Tolerance and error analysis. **08Hrs**
2. **Jigs:** Drill bushes -different types of jigs-plate latch, channel, box, post, angle plate, angular post, turnover, pot jigs-Automatic drill jigs-Rack and pinion operated. Air operated Jigs components. Design and development of Jigs for given components. **06Hrs**
3. **Fixtures:** General principles of boring, lathe, milling and broaching fixtures- Grinding, planning and shaping fixtures, assembly, Inspection and welding fixtures- Modular fixtures. Design and development of fixtures for given component. **06Hrs**
4. **Press Working Terminologies And Elements Of Dies And Strip Lay Out:** Press working terminology-Presses and press accessories-Computation of capacities and tonnage requirements. Elements of progressive combination and compound dies: Die block-die shoe. Bolster plate-punch plate-punch holder-guide pins and bushes - strippers -knockouts-stops - pilots-Selection of standard die sets strip lay out-strip lay out calculations. **08Hrs**
5. **Design and Development of Dies:** Design and development of progressive and compound dies for Blanking and piercing operations. Bending dies - development of bending dies-forming and drawing dies-Development of drawing dies. Design considerations in forging, extrusion, casting and plastic dies. (Use of approved design data book is permitted) **08Hrs**

Text Books:

1. Edward G Hoffman, Jigs & Fixture Design, Thomson – Delmar Learning, Singapore 2004
2. Donaldson. C, Tool Design, Tata McGraw-Hill, 1986.
3. Hiram E Grant, 'Jigs and Fixture' Tata McGraw-Hill, New Delhi, 2003
4. Fundamentals of Tool Design, CEEE Edition, ASTME, 1983
5. PSG College of Technology, Coimbatore - Design Data Handbook.

Reference Books:

1. Kempste, “Jigs & Fixtures Design, The English Language Book Society”, 1978
2. Joshi, P.H., “Jigs & Fixtures, Second Edition”, Tata McGraw-Hill Publishing Company Limited, New Delhi 2004.

E-Books and online learning material:

1. http://www.nitc.ac.in/dept/me/jagadeesha/mev303/CHAPT INTRODUCTION TO J IGS AND%20FIXTURES.pdf
2. http://www.ignou.ac.in/upload/jig.pdf
3. https://www.youtube.com/watch?v=7yzvno4AvKw
4. http://www.cadcam.com.my/pdf/ctc/FundamentalofJigs&FixturesDesign.pdf
5. https://www.youtube.com/watch?v=vOo2MCYPsm4
6. http://www.thegreenbook.com/what-is-the-difference-between-jigs-and-fixtures.htm
7. http://engineeringhut.blogspot.in/2010/11/elements-of-jigs-and-fixtures.html

Subject Code: MME-139 **Subject Name: Machine Tool Design**

Programme:M.Tech.(ME**)**	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 10-20
External Marks:100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Subject Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Understand the various requirements of the machines.
2	Access the various feed drives and spindle drives design on the basis of varying load conditions.
3	Enhance the knowledge regarding the manufacturing aspects of the machining.
4	Get equipped with the knowledge of machine tool dynamics.
5	Evaluate the purpose and principal of tool geometry, construction and design.

Detailed Contents:

1. D**ata Calculation:** Turning: Cutting force, Cutting Speed and Feed Rate. Drilling: Cutting forces, Cutting Speed and Feed Rate. Milling: Chip Section, Cutting force, Milling with Cutter Heads. Grinding: Grinding Forces, Cutting Speed, Feed Rate, and Depth Setting. Planning, Shaping and Broaching. **03 Hrs**
2. **General Requirements of the Machine Tool:** Accuracy of Shape, Dimensional accuracy and surface finish of the components produced. High Productivity. High Technical and Economic Efficiency. **03 Hrs**
3. **Design Principles:** Stiffness and Rigidity of the Separate Constructional Elements and their combined behavior under Load, Static Rigidity, Dynamic Rigidity, Natural frequencies, Damping, Mode of Vibration. **03 Hrs**
4. **Standardization of Spindle Speeds and Feed Rates:** Layout of Speed Change Gears. Saw Diagrams for Arithmetic Progression, Geometric Progression, Harmonic Progression and Logarithmic Progression of spindle speeds for Mechanical Stepped Drives for Machine Tools. Establishment of Gear Ratios, Layout of the Intermediate Reduction Gears, Calculation of Transmission Ratios, Pulley Diameter, Gear Wheel Diameters and Number of Teeth. Ray Diagram. Speed Diagram. **04 Hrs**
5. **Electrical, Mechanical and Hydraulic Drives for the Operational Movements:** Electric Drive and Control Equipment. Mechanical and Hydraulic Drives. Drives for Producing Rotational Movements, Stepped Drives, Step less Drives. Drives for Producing Rectilinear Movements. Backlash Eliminator in the Feed Drive Nut. **04 Hrs**
6. **Automatic Control:** Principles and Constructional Elements. Automatic Driving of the Cutting Movements, Feed Movements, and Return Movements. Automatic control of movements for Starting, Stopping and Reversing. Automatic Clamping and Unclamping the work piece. Automatic Selection of Required Speeds, Automatic Setting of Tools. Automatic Measurement of Machined Shape and Surfaces. Transport of Components from One Machine to the Next. Applications (Examples of Automatic Machines). Control for Moving Slides into Defined, Fixed Positions. Control of Feed Movements in Producing Profiles or Surface by Continuous Path Control **04 Hrs**

7. **Design of Constructional Elements:** Machine Tool Structures, Structural Elements Design for Centre Lathe, Drilling Machine, Knee Type Milling Machine, Planning Machine, Boring Machine, and Grinding Machines. **06 Hrs**
8. **Design of Slide Ways:** Design of Slide ways for Tables, Saddles and Cross-slides. Antifriction Bearings for slide ways. Hydrostatically Lubricated Slide ways. **04 Hrs**
9. **Design of Spindles and Spindle Bearings:** Design of Spindles for Strength and Stiffness. Design of Spindles for Balancing. General Layout and Design of the Driving Elements and the Spindle Bearings. Selection and General Layout of Ball and Roller Bearings for Supporting Spindles. Design of Secondary Drives for Machine Tools, Design of Cutting Drives, Feed Drives and Setting Drives. **05 Hrs**

Text Books

1. Sen and Bhattacharya, "Machine Tools Design", CBS Publisher.
2. N.K. Mehta, "Machine Tool Design", Tata McGraw Hill.
3. N. Acherkan, " Machine Tool Design, Four Volumes" ,Mir Publishers.
4. P. H. Joshi, " Machine Tools *Handbook:* Design *and* Operation", McGraw Hill Professional.
5. S.K. Basu and D.K. Pal, "Design of machine tools", Oxford and IBH.

Subject Code: MME-142 **Subject Name: Product Design and Development**

Program: M.Tech.(ME**)**	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours: 36**
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 10-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Course Status:** Elective

Prerequisites:

Additional Material Allowed in ESE:[Scientific Calculator]

On completion of the course, the student will have the ability to:

CO#	Course Outcomes (CO)
1	Design product as per customer needs and satisfaction
2	Understand Processes and concepts during product development
3	Understand methods and processes of Forward and Reverse engineering
4	Carry various design processes as DFA, DFMEA, design for safety
5	Understand the product life cycle and product data management

Detailed Contents:

Part-A

1. **Introduction to Product Design and Development**: Definition of product design, Essential Factors for product design, Modern approaches to product design, standardization, simplification and specialization in product design product development, product development versus product design, modern product development process, product testing and validation. **06 Hrs**
2. **Product Development –Technical and Business Concerns**: Mission Statement and Technical Questioning, Technology Forecasting and S Curve, Customer Needs and Satisfaction, Customer Needs - Types and Models, tools for Gathering Customer Needs, Customer Population and Market Segmentation. **06 Hrs**
3. **Product Development from Concept to Product Function**: Product information gathering, brainstorming and lateral thinking, morphological analysis of product, generating concepts, concept selection - design evaluation, estimation of technical feasibility, concept selection process, Pugh's concept, selection charts, concept scoring, process of concept embodiment, system modeling, functional modeling and decomposition, fast method, subtract and operate procedure, Simulation driven design. **08 Hrs**
4. **Reverse Engineering**: Product Teardown Process, Tear Down Methods, Force Flow Diagrams, Measurement and Experimentation, Applications of Product Teardown, Benchmarking Approach and Detailed Procedure, Tools Used in Benchmarking Indented Assembly Cost Analysis, Function -Form Diagrams, Trend Analysis, Setting Product Specifications, Introduction to Product Portfolio and Architecture. **08Hrs**
5. **Product Life Cycle Management and Product Data Management**: Introduction, Concept of Product Life Cycle management, Components/Elements of PLM, Customer Involvement, Product Data and Product Workflow, The Link Between Product Data and Product Workflow, Different Phases of Product Life Cycle and corresponding technology. **08Hrs**

Text Books

1. K. Chitale; R.C. Gupta, Product Design and Manufacturing, Prentice Hall India.
2. Dieter George E., Engineering Design McGraw Hill Pub. Company, 2000.
3. Kevin Otto and Kristin Wood, Product Design: Techniques in Reverse Engineering and New Product Development, Pearson Education Inc..
4. Grieves, Michael, Product Lifecycle Management McGraw Hill
5. Bralla, James G., Handbook of Product Design for Manufacturing, McGraw Hill Pub.

Subject Code: MME-143 **Subject Name: Project appraisal and management**

Programme: M.Tech.	**L: 3 T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits: 3**
Internal Marks: 50	**Percentage of Numerical/Design Problems: 20-30**
External Marks: 100	**Duration of End Semester Exam (ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Understand and Improve Project Productivity and Performance.
2.	Generate project ideas and put screening and financial ideas
3.	To understand and measure the risk.
4.	To understand multiple projects, constrain and project management,
5.	Latest scenario of project financing in India

Detailed Contents:

1. **Planning & Analysis Overview:** Phases of capital budgeting – Levels of decision making – objective. Resource Allocation Framework: Key criteria for allocation of resource – elementary investment strategies – portfolio planning tools – strategic position and action evaluation – aspects relating to conglomerate diversification – interface between strategic planning and capital budgeting. **5 Hrs**
2. **Generation and screening of project ideas:** Generation of ideas – monitoring the environment – regulatory framework for projects – corporate appraisal – preliminary screening – project rating index – sources of positive NPV – qualities of a successful entrepreneur – the porter model for estimation of profit potential of industries. Market and demand analysis: Situational analysis and specification of objectives – collection of secondary information – conduct of market survey – characterization of the market – demand forecasting – market planning. Technical analysis: Study of material inputs and utilities – manufacturing process and technology – product mixes – plant capacity – location and site – machinery and equipment – structures and civil works – project charts and layouts – work schedule **5Hrs**
3. **Financial Analysis:** Estimation of cost of project and means of financing – estimates of sales and production – cost of production – working capital requirement and its financing – estimates of working results – breakeven points – projected cash flow statement – projected balance sheet. Project cash flows: Basic principles of measurement of cash flows – components of the cash flow streams – viewing a project from different points of view – definition of cash flows by financial institutions and planning commission – biases in cash flow estimation. Appraisal criteria: Net Present Value – benefit cost ratio – internal rate of returns urgency – payback period – accounting rate of returns – investment appraisal in practice. Analysis of Risk. **5 Hrs**
4. **Types and measure of risk:** simple estimation of risk – sensitivity analysis – scenario analysis – monte Carlo simulation – decision tree analysis – selection of project – risk analysis in practice. Special decision situations: Choice between mutually exclusive projects of unequal life – optimal timing decision – determination of economic life – inter-relationships between investment and financing aspects – inflation and capital budgeting. Analysis of firm and market risk: Portfolio theory and capital budgeting – capital asset pricing model – estimation of key factors – CAPM and Capital budgeting **4 Hrs**

5. **Social Cost Benefit Analysis (SCBA):** Rationale for SCBA – UNIDO approach to SCBA – Little and Mirle approach to SCBA. Introduction to deterministic and probabilistic dynamic programming. The solution to simple problems. **3 Hrs**
6. **Multiple projects and constraints:** Constraints – methods of ranking – mathematical programming approach – linear programming model – Qualitative Analysis: Qualitative factors in capital budgeting – strategic aspects – strategic planning and financial analysis – informational asymmetry and capital budgeting – organizational considerations. Environmental appraisal of projects: types and dimensions of a project – meaning and scope of environment – Environment – Environmental resources values – environmental impact assessment and environmental impact statement. **4 Hrs**
7. **Project financing in India:** Means of finance – norms and policies of financial institutions – SEBI guidelines – Sample financing plans – structure of financial institutions in India – schemes of assistance – term loans procedures – project appraisal by financial institutions. **4 Hrs**
8. **Project Management:** Forms of project organization – project planning – project control – human aspects of project management – prerequisites for successful project implementation. Network techniques for project management – development of project network – time estimation – determination of critical path –scheduling when resources are limit – PERT and CPM models – Network cost system (Only problems on resources allocation and resources leveling) Project review and administrative aspects: Initial review – performance evaluation – abandonment analysis – administrative aspects of capital budgeting – evaluating the capital budgeting system of an organization. **6 Hrs**

Text Books:

1. Prasanna Chandra – Project Planning: Analysis, Selection,Implementation and Review – TMH, 5/e
2. Narendra Singh – Project Management and Control – HPH , 2003
3. Chitkara – Construction Project Management, Planning, Scheduling and Control – TMH, 1/e Choudhury – Project Management – TMH, 1/e
4. Project Management – K Nagarajan – New Age International, 2004
5. Project Management – Merdith & Gopalan – Wiley India (P) Ltd.

Reference Books:

1. Nicholas – Project Management for Business and Technology: Principles and Practice – Pearson / PHI
2. Gray & Larson – Project Management: The Managerial Process –TMH, 3/e , 2005
3. Vasant Desai – Project Management – HPH
4. Bhavesh M Patel – Project Management – Vikas

Subject Code: MME-144 **Subject Name: Entrepreneurship**

Programme: M.Tech.	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** Nil
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Elective Status:** Elective

Additional Material Allowed in ESE: Nil

On Completion of the course, the student will have the ability to:

CO	Course Outcomes
1.	Concept and theories of entrepreneurship and its role in economic development.
2.	Develop business plan and identify the reasons of failure of business plans.
3.	Illustrate the steps in starting MSME & Provide solution to real life entrepreneurial /MSME problems.
4.	Comprehend government policies and regulatory framework available in India to facilitate the process of entrepreneurial development.
5.	Identify different sources of finance for new enterprises and assess the role of financial institutions and various government schemes in entrepreneurial development

Detailed Contents:

1. **Basics of Entrepreneurship:** Concept & Theories of Entrepreneurship, Myths about Entrepreneurship, Entrepreneurial Traits and Motivation, Role of Entrepreneurship in economic development. Types of Entrepreneurs. Barriers in the way of Entrepreneurship. Entrepreneurship Development (ED) Cycle. Entrepreneurship development programmes (EDP). **6 Hrs**
2. **Identification of Investment Opportunities:** Creativity and Business Ideas, Blocks to creativity. Business Plans and reasons of failure of business plans. Micro-Small-Medium Enterprise (MSME) & its role in developing countries- Steps and problems for starting. Government policies for industry and regulatory framework, foreign collaboration and investment. Scouting for project ideas, preliminary screening & pilot run /prototype modeling. Rural Industry: Establishment, Development & Challenges. **6 Hrs**
3. **Market and Demand Analysis:** Information required for market and demand analysis, market survey, demand forecasting, uncertainties in demand forecasting, Value Engineering.
4. **System Management:** Enterprise Resource Planning (ERP), Customer Relationship Management, Grievance Redressal System, Need based production, Vendor Management, Supply Chain Management. **6 Hrs**
5. **EDP in India South Asia and World:** Phases of Entrepreneurial programs – Government Policies & Initiatives, Administrative Frame work, Policy instruments , Statutory Boards , Industrial Estates, Industrial clusters, Incentives and subsidies, Promotional agencies. Business Incubators& Start-ups. **6Hrs**
6. **Financial Management:** Cost estimation, Types of capital, Budget Management, Bridge capital, Seed capital assistance, Margin money scheme, Industrial Sickness, Causes-Remedies- An overview on the roles of institutions/schemes in entrepreneurial development- SIDBI,

Commercial Banks. Other financing options- venture capital, lease funding, Angel Investors. Revival, Exit and End to a venture. **6 Hrs**

Text Books:

1. Kumar & Arya, "Entrepreneurship", Pearson, New Delhi.
2. Gopal & Nanda , "Entrepreneurial Development", Vikas Publishing, New Delhi.
3. Desai & Vasant, "Dynamics of Entrepreneurial Development & Management", Himalaya Publishing House.
4. Khanka,S S "Entrepreneurial Development", S.Chand & Co.,New Delhi.
5. Angadi, Cheema & Das, "Entrepreneurship, Growth & Economic Integration.", Himalya Publishing House.

Subject Code: MME-145 **Subject Name: Safety Engineering**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:**10-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Use and design safety equipment /systems effectively.
2.	Understand the methods of hazard identification and preventive measures
3.	Apply the methods of prevention of fire and explosions.
4.	Understand the control and relief and methods.
5.	Maintain the safer environment in the industry

Detailed Contents:

1. **Safety**: Measuring and need for safety. Relationship of safety with plant design, equipment design and work environment. Use of various Personal Protective Equipment (PPEs), Industrial accidents, their nature, types and causes. Assessment of accident costs; prevention of accidents. Industrial hazards, Hazards identification techniques, accident investigation, reporting and analysis. **6Hrs**
2. **Ventilation and heat control**: Purpose of ventilation. Physiology of heat regulation. Thermal environment and its measurement. Thermal comfort. Indices of heat stress. Thermal limits for comfort, efficiency and freedom from health risk. Types of ventilation. Air conditioning process & types. **6Hrs**
3. **Industrial Lighting:** Purpose of lighting, benefits of good illumination, Phenomenon of lighting and safety, Lighting at work source, types of artificial lighting. Principles of good illumination. Recommended optimum standards of illumination. Design of lighting system. Maintenance standard relating to lighting and colour. **7Hrs**
4. **Noise and Vibrations:** Various types of noise. The effect of noise on worker. Noise measurement and evaluation of noise. Noise control techniques. Vibrations; Effect, types, measurement and control measures. **7Hrs**
5. **Fire, Explosion & Prevention:** The fire triangle, Distinction between Fires and Explosions, Flammability Characteristics of Materials, Ignition Sources, Sprays and Mists. Concepts to Prevent Fires and Explosions: Static Electricity and its Control, Explosion-Proof Equipment and Instruments, Ventilation, Sprinkler Systems, Fire- fighting equipment. **5Hrs**
6. **Miscellaneous:** Safety and economics, safety and productivity. Employees' participation in safety. Safety standards and legislation. First aid provisions and training. **5Hrs**

Text Books:

1. Gupta, A.K., "Industrial Safety & Environment" Laxmi Publishers.
2. Asfahal, C.R. and Rieske, D.W., "Industrial Safety and Health Management", Pearson.
3. Hammer, W. and Price, D., "Occupational Safety Management and Engineering". Pearson.
4. DC Reamer; R, "Modern Safety & Health Technology", Wiley.
5. Heinrich, H.W., "Industrial Accident prevention", McGraw Hill.

Subject Code: MME-146 **Subject Name: Quality Assurance**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:**10-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Quality Assurance

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	To learn the basic concepts of quality and quality from organizational point of view.
2.	To learn the concept of total quality management from western and Japanese approach.
3.	Statistical basis for control charts, Causes of variation, To construct Control chart for a manufacturing process/service activities.
4.	To learn about QMS standards
5.	To be aware of international/national Quality awards.

Detailed Contents:

1. **Evolution of Quality:** Historical Perspective, Basic Concepts of Quality, Vision, Mission and Objectives of an Organization, Corporate Structure in an Organization and Role of Quality. **05Hrs**
2. **Quality Planning:** Quality by Design, Quality Costs and Cost of Failure, Waste Control, How Quality Benefits Business. **04Hrs**
3. **Quality and Competitiveness in Business:** Zero Defects and Continuous Improvement, Role of Leadership and Commitment in Quality Deployment, Team Building, Motivation and Rewards, Total Employee Empowerment, Quality Functions - Measurement, Inspection, Testing, Calibration and Assurance. **06Hrs**
4. **Control Charts for Variables**: X Bar-R Charts, X Bar-s Charts, Individual Item (MR) Charts, and Control Charts for Attributes - p-Charts, np-Charts, c-Charts, u-Charts, U Bar Charts. **08Hrs**
5. **Implementing Total Quality Management**: An Integrated System Approach,Total Preventive Maintenance.Self-Assessment, International/National Quality Awards: Malcolm Baldridge Award, Deming Prize, European Award, Rajeev Gandhi Award, CII Exim Award, Jamna Lal Bajaj Award, Golden Peacock Award. **8Hrs**
6. **Evaluating Sampling Plans:** AQL, AOQ, and AOQL, Taguchi's Loss Function. **5Hrs**

Text Books:

1. Amitava mitra,A John Wiley & Sons, Quality Control and Improvement, Inc., Publication,2001.
2. Dale H. Besterfield, Carol Besterfield-Michna, Total Quality Management , Pearson Education, 2005
3. I. R. Miller, J. E. Freund & R. Johnson, Probability and statistics for Engineers, Prentice Hall of India, 2002

4. Abraham Silberschatz, S. Sudarshan, Henry F. Korth, “Database System Concepts”, 6th Edition, Tata McGraw - Hill Education, 2011.
5. N.V.R Naidu, G. Rajendra, Total Quality Management New Age international, ,First Edition,Jan 2006.

Reference Books:

1. Joseph Juran, Juran's Quality Handbook, McGraw Hill, 1999.
2. B. L. Hanson & P. M. Ghare, Quality Control & Application Prentice Hall of India, 2007.

Subject Code: MME-147 **Subject Name: Materials Management**

Programme:B.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 10-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Status:** Elective

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#.	Course Outcomes (Cos)
1	Explain the scope and function of material management.
2	Develop the functions of purchasing, inventory management and receiving & shipping.
3	Apply business functions in the dynamic environment.
4	explain inventory control techniques and evaluate different inventory alternatives/strategies
5	Analyze distinct concepts within material management and explain how these can be use materials and products in Industries.

Detailed Contents:

1. **Material Management:** Scope and importance of materials and inventory Management, Functions and objectives of material Management. Introduction to Material Planning, Factors affecting Material Planning, Classification and Codification of Materials, Standardization and Simplification. **8Hrs**
2. **Purchasing:** Introduction to Purchasing, Classification of Purchases, Principles of Scientific Purchasing, Objectives and functions of purchasing, Purchase Techniques, Purchasing Procedure, Quality considerations in purchasing. **7Hrs**
3. **Material Handling:** Primary Handling activities- Receiving, In-storage Handling and shipping, Basic Handling Considerations, receiving functions. **5Hrs**
4. **Inventory Control:** Inventory Costs, Inventory Classification, Inventory Management, Demand of Inventory, , lead time, stock outs, Lot Sizing, Push System vs. Pull System Inventory Control, Inventory Control Systems, Basic Stock Control Methods, Economic Order Quantity (EOQ) Models, Deterministic and Stochastic Models, EOQ and Quantity Discount, EOQ Model with Non-Instantaneous Receipt, EOQ Model with Planned Shortages, Finding the Optimal Order & Back Order Level Production Lot Size with Planned Shortages, simulation models for inventory analysis. **10Hrs.**
5. **Store Management:** Concept, Responsibilities and functions of store management, Types of stores, Coding, Store Accounting and Store Verification, Management of Surplus, Scrap and Obsolete Items. **6Hrs**

Text Books:

1. Bhagde, S.D, "Production and Materials Management", U.S.G Publishers, 1995.
2. Plossl, G.W& Wight, O.W., "Production and Inventory Control", Prentice Hall, 1967.
3. Mahajan, M., "Industrial Engineering and Production Management", Dhanpat Rai & Co., 2007.
4. Chary, S.N., "Production and Operations Management", Tata McGraw Hill.
5. Arora, K.C., "Production and Operations Management", Laxmi Publications.

Reference Books:

1. Chary, S.N., “Production and Operations Management”, Tata McGraw Hill.
2. Arora, K.C., “Production and Operations Management”, Laxmi Publications.

Subject Code: MME-148 Subject Name: Organization Theory and Behaviour

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:1**0-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status: Elective**

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Desribe the concept of organisation theory and behavioura at all levels
2.	Analyse the importance of individual as well as group decision making in an organisation.
3.	Apply the concept of theory, behaviour and culture in totality
4.	Address the importance of various motivational theories
5.	Development of organization by doing SWOT analysis

Detailed Contents:

1. **Organizational Theories and Behaviour**: Classical, Neo-classical and Contemporary. Authority, Power, status, formal and informal structure. Flat and Tall structures. The bureaucratization of organizations. Organisational Behaviour-concepts, determinants, models, challenges and opportunities of OB. Transaction cost and organizational behaviours Contributing disciplines to the OB. Individual Behaviour: Foundations of individual behavior, values, attitudes, personality and emotions. Theory X and Theory Y, Chris Argyris behavior patterns, Perceptual process. **9 Hrs**
2. **Group Decision making:**Concept and nature of decision-making process, Individual versus group decision making, Nominal group technique and Delphi technique, models of communication, communication effectiveness in organizations. Feedback, TA, Johari Window, Maslow's Need Hierarchy, Two-factor theory, Contemporary theories of motivation (ERG, Cognitive evaluation, goal setting, equity) expectancy model. Behavior modification, Motivation, and organizational effectiveness. **9 Hrs**
3. **Leadership, Power, and Conflict**: Concept and theories, Behavioral approach, Situational approach, Leadership effectiveness, Contemporary issues in leadership, Power and conflict, Bases of Power, power tactics, sources of conflict patterns, levels, and conflict resolution strategies. **8 Hrs**
4. **Organisational Culture, Organisational Development, and Stress Management**: Concept and determinants of organizational culture, Organisational Development: concept and intervention techniques, Individual and organizational factors to stress, consequences of stress on individual and organization, management of stress. **10 Hrs**

Text Books:

1. Robbins; S.P., Organisational Behaviour (13th edition), Prentice Hall of India Pvt. Ltd., New Delhi, 2008.
2. Luthans, Fred, Organisational Behaviour, 11th Edition, Mc Graw Hill International, New York, 2007.
3. Robins S.P., Organisational Theory: Structure Design and Application, 3 rd ed., Prentice-Hall of India Pvt. Ltd., 2007.
4. Wagner-Tsukamoto, Sigmund. "Human nature and organization theory." Books (2003).
5. Tsoukas, Haridimos, and Christian Knudsen, eds. The Oxford handbook of organization theory. Oxford Handbooks, 2005.

Subject Code: MME-149 **Subject Name: Business Policy and Strategies**

Programme: M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:**10-20
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course the student will have the ability to:

CO #	Course Outcomes
1.	Evolution and significance of Business Policy
2.	Formulation of various business strategies
3.	Analyse business strategies from Holistic point of view
4.	Implementation of strategies in large, medium and short range programming
5.	Evolve various business strategies by conducting case study

Detailed Contents:

1. **Introduction:** Business policy-evolution of the concept. Difference between business policy and strategic management. Corporate governance- concept, issues, models, evolution and significance. Introduction to Strategic Management- Concept importance of strategic Management, Strategy & Competitive Advantage, Strategy Planning & Decisions, strategic Management Process. **8 Hrs**
2. **Top management perspective:** Establishing company direction-developing strategic vision, setting objectives and crafting a strategy-Internal & External Environment, Formulating Long Term objective & Strategy, Strategic Analysis & Choice. **10 Hrs**
3. **Analyzing business environment:** Analysis of Business environment at 3 levels-Macro external environment analysis, external environment analysis (Industry analysis and competitor analysis) porter's five forces and competitor analysis framework, and firm level internal analysis. **6Hrs**
4. **Competitive strategy and competitive advantage:** Industry and competitive analysis, strategy and competitive advantage, Principles of Competitive Advantage-Identifying Value Activities, Competitive Scope and the Value Chain, the Value Chain and Generic Strategies, Mergers & Acquisitions Strategies, Grand strategies: stability, growth, retrenchment & combination strategies, Corporate planning in India, Implementation of strategy- developing organization structure and climate, medium and short range programming, Relevant case studies. **12 Hrs**

Text Books:

1. Business Policy and Strategy by Chris Chatfield, Cheryl Van Deusen, Steven Williamson, Harold C. Babson, Auerbach Publications 2007
2. Business Policy and Strategy: Policy & Corporate Strategy by jitendra kushwaha and Pallavi J, Kindle Edition, 2020
3. Business Policy- Kazmi, M.M. Tata McGraw Hill 1992
4. Business Policy- Balasubramaniam Kalyani Pub. 1992
5. Business Policy- Ghosh, P.K. Sultan Chand & Sons 1990

Subject Code: MOME-151 **Subject Name: Business Analytics**

Programme:M.Tech. (ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems:** 20-30
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Status:** Open Elective

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#.	Course Outcomes (Cos)
1	Explain the basics of business analysis and Data Science.
2	Explain the data management and handling.
3	Analyze the Data Science Project Life Cycle.
4	Apply the data mining concept and its techniques.
5	Analyze the machine learning concept.

Detailed Contents:

1. **Introduction:** What is business analytics? Historical Overview of data analysis, Data Scientist vs. Data Engineer vs. Business Analyst, Career in Business Analytics, What is data science, Why Data Science, Applications for data science, Data Scientists Roles and Responsibility. **8Hrs**
2. **Data and Data Science Project Life Cycle:** Data Collection, Data Management, Big Data Management, Organization/sources of data, Importance of data quality, Dealing with missing or incomplete data, Data Visualization, Data Classification. Data Science Project Life Cycle: Business Requirement, Data Acquisition, Data Preparation, Hypothesis and Modeling, Evaluation and Interpretation, Deployment, Operations, Optimization. **9Hrs**
3. **Data Mining:** Introduction to Data Mining, The origins of Data Mining, Data Mining Tasks, OLAP and Multidimensional data analysis, Basic concept of Association Analysis and Cluster Analysis. **6Hrs**.
4. **Machine Learning:** Introduction to Machine Learning: History and Evolution, AI Evolution, Statistics Vs Data Mining Vs, Data Analytics Vs, Data Science, Supervised Learning, Unsupervised Learning, Reinforcement Learning, Frameworks for building Machine Learning Systems. **9Hrs**
5. **Application of Business:** Retail Analytics, Marketing Analytics, Financial Analytics, Healthcare Analytics, Supply Chain Analytics. **4Hrs**

Text Books:

1. Bhimasankaram Pochiraju and Sridhar Seshadri, "Essentials of Business Analytics: An Introduction to the methodology and its application", Springer, 2010.
2. Andreas C. Müller, Sarah Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists", O'Reilly, 2018.
3. Laura Igual and Santi Segui., "Introduction to Data Science", Springer, 2017.
4. Kumar, U. Dinesh. Business analytics: The science of data-driven decision making. Wiley, 2017.
5. Jank, Wolfgang. Business analytics for managers. Springer Science & Business Media, 2011.

Reference Books:

1. Pang-Ning Tan, Michael Steinbach and Vipin Kumar., “Introduction to Data Mining”, Pearson Education India.
2. Ger Koole., “An Introduction to Business Analytics”, Lulu.com, 2019.

Subject Code: MOME-152 **Subject Name: Industrial Safety**

Programme: M.Tech.	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems: 20-30**
External Marks: 100	**Duration of End Semester Exam (ESE):** 3hours
Total Marks: 150	**Course Status:** Open Elective

Prerequisites: Nil

Additional Material Allowed in ESE: Nil

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Explain the basic terminology, legislation and standards involved in Industrial Safety.
2.	Recognizing the factors contributing towards Industrial Hazards and Accidents.
3.	Apply various preventive measures to ensure Industrial Safety.
4.	Demonstrate the concept of Wear and Corrosion and their prevention.
5.	Identify of faults in machine tools and their general causes.

Detailed Contents:

1. **Industrial safety**: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods. **6Hrs**
2. **Fundamental of maintenance engineering**: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.**6 Hrs**
3. **Wear and Corrosion and their prevention:** Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods. **7 Hrs**
4. **Fault tracing:** Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes. **7 Hrs**
5. **Periodic and preventive maintenance**: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: i. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance. **10Hrs**

Text Books:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Subject Code: MOME-153 **Subject Name: Operation Research**

Programme: M.Tech.	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36 Hours
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems: 70-80**
External Marks: 100	**Duration of End Semester Exam (ESE):** 3hours
Total Marks: 150	**Course Status:** Elective

Prerequisites: NIL

Additional Material Allowed in ESE: NIL

On completion of the course, the student will have the ability to:

CO#	Course Outcomes
1.	Understand the characteristics of different types of operations research models in real-life environments.
2.	Application of different types of deterministic and probabilistic models in finding real-life environments.
3.	Design new simple models, like CPM, to improve decision making.
4.	Implement the various OR tools for better decision making.
5.	Identify and apply the appropriate operation research model.

Detailed Contents:

1. **Introduction**: Origin of OR and its role in solving industrial problems: General approach for solving OR problems. Classification of mathematical models: various decision-making environments. **3 Hrs**
2. **Deterministic Models**: Formulation of deterministic linear mathematical models: Graphical and simplex techniques for solving linear programming problems, Big M method Introduction to duality, duality theorem and sensitivity analysis. **6 Hrs**
3. **Transportation Models:** North-west corner rule, Row minima method, Column minima method, least cost method and Vogel approximation method (VAM), Optimization of transportation problem using Stepping stone and MODI method. **4 Hrs**
4. **Assignment, Sequencing Models:** Hungarian method/algorithm, Optimization of assignment problem, Johnson rule. **5 Hrs**
5. **Dynamic Programming**: Introduction to deterministic and probabilistic dynamic programming. The solution of the simple problems. **3 Hrs**
6. **Queuing theory:** Types of the queuing situation: Queuing models with Poisson's input and exponential service, their application to simple situations. **5 Hrs**
7. **Network models:** Shortest route and traveling salesman problems, PERT & CPM introduction, analysis of time-bound project situations, construction of networks, identification of critical path, slack and float, crashing of a network for cost reduction, resource leveling and smoothening. **6Hrs**
8. **Solving LPs using Solver:** Setting up the problem and solving simple LP problems, Transportation problems and Assignment problems. **3 Hrs**

Text Books:

1. P. K., Gupta and D. S., Hira, *Operations Research,* S. Chand Limited, India, 2008.

2. D. M., Miller, and J. W., Schmidt, *Industrial Engineering and Operations Research*, John Wiley & Sons, Singapore, 1990.
3. H. A., Taha, *Operations Research*, Pearson, 2004.
4. R., Paneerselvam, *Operations Research*, Prentice Hall of India, New Delhi, 2008.
5. G., Srinivasan, *Operations Research-Principles and Applications*, PHI Pvt. Ltd., 2010.

Reference Books:

1. P., Ramamurthy, *Operations Research*, New Age International (P) Limited, 2007.
2. R., Pannerselvam, *Design and Analysis of Algorithms*, Prentice Hall of India, New Delhi, 2007.
3. A. P., Verma, *Operations Research*, S.K. Kataria & Sons, 2013.

E-Books and Online Learning Material

1. Operations Research - A Model-Based Approach by H. A. Eiselt, Carl-Louis Sandblom, Springer Texts in Business and Economics https://www.kobo.com/us/en/ebook/operations-research Accessed in June 2021
2. Introduction to Operations Research- Deterministic Models by Juraj Stacho https://www.cs.toronto.edu/~stacho/public/IEOR4004-notes1.pdf Accessed in June 2021

Online Courses and Video Lectures

2. https://nptel.ac.in/courses/112/106/112106134/ Accessed in June 2021
3. https://nptel.ac.in/courses/112/106/112106131/ Accessed in June 2021
4. https://nptel.ac.in/courses/110/106/110106059/ Accessed in June 2021

Topics for Self-Learning

1. Two-phase method.
2. Degeneracy in linear programming problems.
3. Dual simplex method and Revised simplex method.
4. Dual transportation problem, Traveling salesman problem.
5. System reliability.

Subject Code: MOME-154 Subject Name: Cost Management of Engineering Products

Programme:M.Tech.(ME)	**L:** 3 **T:** 0 **P:** 0
Semester: 2nd /3rd	**Teaching Hours:** 36
Theory/Practical: Theory	**Credits:** 3
Internal Marks: 50	**Percentage of Numerical/Design Problems: 20-30**
External Marks: 100	**Duration of End Semester Exam(ESE):** 3hr
Total Marks: 150	**Status:** Elective

Additional Material Allowed in ESE: Scientific Calculator

On completion of the course, the student will have the ability to:

CO#.	Course Outcomes (Cos)
1	Understand the concept of cost management and its importance in today's industry
2	Utilize strategic cost management for various engineering products
3	Explain different methods for costing of an product manufactured by an organization
4	Describe marginal costing, overheads and concept of budgetary control in cost management of products
5	Illustrate cost auditing practices in an organization
6	Analyze the various costs determining costing of products.

Detailed Contents:

1. **The strategic cost management process:** Introduction and Overview of the Strategic Cost Management Process, Cost Concepts for Decision-Making, Cost Behavior and Profit Planning, Cost Reduction and Cost Control, Techniques of Costing, Preparation of Cost Sheets for manufacturing sector. **6Hrs**
2. **Costing methods:** A Review of Product Costing, job costing, batch costing, contract costing, Overhead Allocation and Decision-Making, Variable Costing and Throughput Accounting, Activity-Based Costing and Customer Profitability. **6Hrs**
3. **Ascertainment of Cost and Cost Accounting System:** Material Cost: Procurement procedures, Store procedures and documentation in respect of receipts and issue of stock. Inventory control: Techniques of fixing level of stocks- minimum, maximum, re-order point, safety stock, determination of optimum stock level, Determination of Optimum Order quantity-Economic Order Quantity (EOQ), Techniques of Inventory control- ABC Analysis, Fast, Slow moving and Non moving (FSN), High, Medium, Low (HML), Vital, Essential, Desirable (VED), Just-in-Time (JIT)Inventory Accounting Employee Cost: Elements of wages- Basic pay, Dearness Allowance, Overtime, Bonus, Holiday and leave wages, Allowances and perquisites. Direct and indirect employee Cost, charging of employee cost. **6Hrs**
4. **Overheads:** Overheads, Classification and Collection, Difference between Cost Allocation and Cost Apportionment, (Full-fledged Problems on Primary and secondary distribution, Simultaneous equations, Absorption of Overhead, Theory on Under and Over absorption of Overhead). **6Hrs**
5. **Marginal Costing:** Marginal Costing – Nature and Scope- Applications-Break even charts and Point, Decision Making (all types with full problems) Differential Cost Analysis, Advantages and Disadvantages of Marginal Costing. **6Hrs**
6. **Cost Audit& Reporting to Management:** Objectives and advantages of Cost Audit, Cost Audit report .Management Audit- Objectives and Scope. Reporting to Management – Purpose of reporting-Requisites of a good report,, Classifications of Report, Segment reporting, Cost

Reduction and Cost Control, Target Costing – its Principles, Balanced Scorecard: Features and Purpose. **6Hrs**

Text Books:

1. S.P. Jain and K.L. Narang,Cost and Management Accounting Kalyani Publishers
2. V.K. Saxena & C.D. Vashist, Cost and Management Accounting Sultan Chand & Sons
3. Blanchard, Benjamin S., and Benjamin S. Blanchard. Logistics engineering and management. Vol. 47. New Jersey: Pearson Prentice Hall, 2004.
4. Agndal, Henrik, and Ulf Nilsson. "Interorganizational cost management in the exchange process." Management Accounting Research 20.2 (2009): 85-101.
5. Martin, James N. Systems engineering guidebook: A process for developing systems and products. CRC press, 2020.

Reference Books:

1. M.N. Arora Cost and Management Accounting (Theory and Problems), Himalaya Publishing House
2. M.Y. Khan & P.K. Jain Theory and Problems of Management and Cost Accounting, McGraw-Hill Education