UG Curriculum-2020
of
B. Tech. in Mechanical Engineering

School of Technology

Pandit Deendayal Energy University

Course Structure of B. Tech. Mechanical Engineering

Approved in 2020-21 and w.e.f. Admission Batch: 2019

Program Educational Objectives (PEOs)

1. To prepare the graduates with strong foundation in science and engineering for successful careers in core mechanical and interdisciplinary industries, higher education and research.
2. To prepare graduates who can become entrepreneur/innovators to design and develop system/process/product/service to address social and industrial challenges.
3. To prepare graduates with leadership qualities, strong communication skills, professional and ethical values.
4. To prepare lifelong learners graduates to excel in their professional career as well as to pursue higher education.

Program Outcomes (POs)

1. **Engineering knowledge:** An ability to apply knowledge of mathematics, science, and engineering in solving/analyzing problems in industries, research and development institutions, public sector units, higher education and in academia.
2. **Problem Analysis:** An ability to design and conduct experiments, as well as to analyze and interpret data in mechanical engineering theory and practice at various industrial work-places.
3. **Design/ Development of solutions:** An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, health and safety, manufacturability, and sustainability.
4. **Multidisciplinary Approach:** An ability to function on multidisciplinary teams.
5. **Modern tool usage:** An ability to identify, formulate, and solve engineering problems using modern tools and techniques.
6. **Communication:** An ability to communicate effectively.
7. **The Engineer and Society:** The broad education necessary to understand the impact of mechanical engineering solutions in a local, global, economic, environmental, and societal context.
8. **Life-long learning:** A recognition of the need for, and an ability to engage in life-long learning.
9. **Investigations of complex problem:** Use of Applied research including design of experiments, analysis and interpretation of data, synthesis of the information to provide valid solutions with the knowledge of contemporary issues.
10. **Project Management:** An ability to apply engineering knowledge and management principles skills to manage engineering projects.
11. **Environment and Sustainability:** An ability to design sub-systems, systems, components and processes to fulfil demand of environmental sustainability.
12. **Ethics:** Apply engineering principles toward the professional values and ethics.

Program Specific Outcomes (PSOs)

1. To **analyze the problems** and **create solution** by applying engineering knowledge with a multidisciplinary approach in the area of thermal engineering, manufacturing systems and product design.
2. To analyze, interpret and provide solutions to the real life mechanical engineering problems **using engineering software/tools.**
3. **To work effectively in a team** to address **complex issues** by engaging in **lifelong learning** and following **ethical and environmental** practices

Sem-I, Sem-II, Sem-III, Sem-IV, Sem-V, Sem-VI, Sem-VII, Sem-VIII

Course Structure of B. Tech. in Mechanical Engineering

COURSE STRUCTURE FOR B.TECH. SECOND YEAR (Mechanical Engineering)

SEMESTER III (Subjects)				B.TECH. SECOND YEAR (Mechanical Engineering)											
Sr. No.	Category Code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
				L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
									CE	MS	ES	CE	ES	
1	BSC	20MA202T	Mathematics – III	3	1	0	4	4	25	25	50	-	-	100
2	PCC	20ME201T	Thermodynamics	3	0	0	3	3	25	25	50	-	-	100
3	PCC	20ME201P	Thermodynamics - Lab.	0	0	2	1	2	-	-	-	25	25	50
4	PCC	20ME202T	Strength of Material	3	0	0	3	3	25	25	50	-	-	100
5	PCC	20ME202P	Strength of Material - Lab.	0	0	2	1	2	-	-	-	25	25	50
6	PCC	20ME203T	Mechanical Measurements & Metrology	3	0	0	3	3	25	25	50	-	-	100
7	PCC	20ME203P	Mechanical Measurements & Metrology - Lab.	0	0	2	1	2	-	-	-	25	25	50
8	OE	20ME204T	Open Elective - I	3	0	0	3	3	25	25	50	-	-	100
9	HSC	20HS201P	Communication Skills - II	0	0	2	1	2	-	-	-	50	50	100
			Total	**15**	**1**	**8**	**20**	**24**						

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

20MA202T					Mathematics-III: Mechanical Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs./Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	1	0	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To apply Fourier analysis for solving applications in mechanical and other engineering branches.
- To familiarize students with a variety of engineering problems that can be handled by special functions where the analytical methods fail.
- To provide a broad coverage of various mathematical techniques that are widely used for solving and to get analytical solutions to partial differential equations of first and second order.
- To introduce different techniques to develop first or second order partial differential equations and their solution in variety of Mechanical fields.

UNIT 1 FOURIER SERIES AND APPLICATIONS IN MECHANICAL ENGINEERING **10 Hrs.**

Periodic functions, odd and even functions, Euler's formulae for Fourier series in an interval of length 2 pi, change of interval, Dirichlet's conditions, half range Sine and Cosine series, complex Fourier series, Parseval's identity and its applications in Mechanical Oscillations, Applications of Fourier Series in Periodic variation of gas pressure in a 4-stroke internal combustion engine Or the study of Crank rotation in respect of Fourier Series.

UNIT 2 SPECIAL FUNCTIONS **10 Hrs.**

Power series method to solve the differential equation, Frobenius method for solution near regular-singular points, Legendre's equation, Legendre Polynomials, Rodrigue's formula, Bessel's equation, orthogonality conditions and generating functions for Legendre and Bessel's equations.

UNIT 3 PARTIAL DIFFERENTIAL EQUATIONS OF FIRST ORDER **10 Hrs.**

Formation of Partial Differential Equations (PDEs), Solutions of PDEs of first order, Cauchy problem for first order PDEs, Lagrange's method, Charpit and Jacobi methods for solving first order nonlinear PDEs

UNIT 4 PARTTIAL DIFFERENTIAL EQUATIONS OF SECOND ORDER WITH APPLICATIONS **10 Hrs.**

Classification of second order PDEs, method of separation of variables, Fourier series solutions of one-dimensional wave equation, one dimensional heat equation, steady state solution of two-dimensional heat equation, applications of PDEs to string and rod problems pertaining to Mechanical Systems

40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Identify** the role of periodic functions in real world problems.
CO2 – **Understand** the various techniques to analyze the behavior of different Mechanical periodic systems such as 4 – stroke engines.
CO3 – **Solve** the differential equations which are not solvable by analytical methods known so far and thus develop a skill to look for alternatives.
CO4 – **Discuss** the role of partial derivatives in engineering problems where multiple factors affect the system.
CO5 – **Evaluate** physical problems involving partial derivatives.
CO6 – **Develop** the ability to model the physical systems in terms of the methods learnt in this course and then solve accordingly.

TEXT/REFERENCE BOOKS

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons 10th Edition, (2016)
2. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers 44th Edition, (2017)
3. R.K. Jain & S.R.K. Iyengar, Advanced Engineering Mathematics, 3rd Ed., Narosa Publishing House, (2002).
4. Tai-Ran Hsu, Applied Engineering Analysis, John Wiley & Sons, (2018)
5. K. S. Rao: Introduction to Partial Differential Equations, PHI Learning Pvt Ltd, New Delhi, (2010)
6. T. Amaranath: An Elementary Course in Partial Differential Equations, Narosa Publishing House, New Delhi, (2003)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs.**
Part A: 6 questions 5 marks each	30 Marks (60 min)
Part B: 5 questions 8 marks each	40 Marks (80 min)
Part C: 2 questions 15 marks each	30 Marks (40 min)

20ME201T					Thermodynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVE

- To explain the fundamentals of Thermodynamics including thermodynamic system and properties, relationship among thermo-physical properties, the laws of thermodynamics and applications of these basic laws in thermodynamic systems.

UNIT 1 Laws of Thermodynamics (15)

First law of thermodynamics: Concept of energy and various forms of energy; internal energy, enthalpy; specific heats; first law applied to elementary processes, closed systems and control volumes, steady and unsteady flow analysis; **Second law of thermodynamics:** Limitations of the first law of Thermodynamics, concept of heat engines and heat pumps/refrigerators, Kelvin-Planck and Clausius statement and their equivalence; reversible and irreversible processes; Carnot cycle and Carnot principles/theorems; Thermodynamic temperature scale; Calusius inequality and concept of entropy; microscopic interpretation of entropy, the principle of increase of entropy, T-s diagrams; **Exergy Analysis:** Entropy, Second law analysis for a control volume, Irreversibility and availability, Exergy balance equation and Exergy analysis, 3rd law of Thermodynamics, Availability in steady flow open and closed system, third law of thermodynamics

UNIT 2 Properties of pure substances and Thermodynamic relations (10)

Properties of pure substances: Thermodynamic properties of pure substances in solid, liquid and vapour phases, P-v-T behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state; law of corresponding states, compressibility factor and generalized compressibility chart, **Thermodynamic relations:** T-ds relations, Helmholtz and Gibbs functions, Maxwell relations, Joule-Thomson coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron and Clapeyorn-Clausius equations

UNIT 3 Thermodynamic cycles (10)

Vapour power cycle: Carnot vapor cycle, Rankine cycle, comparison of Carnot and Rankine cycle, calculation of cycle efficiencies, variables affecting efficiency of Rankine cycle, reheat cycle, regenerative cycle, reheat-regenerative cycle, feed water heaters **Gas power cycles:** Recapitulation of Carnot, Otto and Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles, air standard efficiency, mean effective pressure, brake thermal efficiency, relative efficiency, Simple Brayton cycle

UNIT 4 Ideal gas mixtures and Combustion (10)

Ideal gas mixtures: Dalton's and Amagat's laws, properties of ideal gas mixtures and simple thermodynamic processes involving them, specific and relative humidities, dew point and wet bulb temperature, adiabatic saturation temperature, psychrometric chart, **Combustion:** Combustion equations, stoichiometric air fuel ratio, enthalpy of formation, adiabatic flame temperature, determination of calorific values of fuels – calorimeter - Bomb and Junkers gas calorimeter

Max: 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Use thermodynamic terminology correctly.
CO2: Explain fundamental thermodynamic properties.
CO3: Explain what sources of energy there are in a thermodynamics system.
CO4: Derive and discuss the first and second laws of thermodynamics.
CO5: Solve problems using the properties and relationships of thermodynamic fluids.
CO6: Analyze basic thermodynamic cycles.

TEXT/REFERENCE BOOKS

1. Cengel Y A and Bole M A, Thermodynamics: An Engineering Approach, 8th Edition, McGraw Hill (2014)
2. Nag P K, Engineering Thermodynamics, 6th Edition, McGraw Hill (2017)
3. Rayner Joel, Basic Engineering Thermodynamics, 5th Edition, Pearson (2008)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME201P					Thermodynamics Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVE

- To gain insight into basic concepts taught in Thermodynamics theory course by performing hands on experiments.

List of Experiments:

1. Introduction to reciprocating air compressor.
2. Performance test on Reciprocating air compressor.
3. To calculate the calorific value of a liquid fuel by bomb calorimeter.
4. To study the working of single cylinder diesel engine and analyze by Engineering Equation Solver (EES).
5. Load test on four stroke single cylinder diesel engine.
6. Heat balance test on four stroke single cylinder diesel engine.
7. Measurement of dryness fraction by Separating Calorimeter, Throttling Calorimeter, Separating and Throttling Calorimeter
8. To study a steam power plant cycle.
9. Exergy analysis of single cylinder four stroke diesel engine.
10. Exergy analysis of reciprocating air compressor.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Evaluate and discuss experimental uncertainty.
CO2: Apply first law and second law of thermodynamics to various thermal systems.
CO3: Evaluate the performance of thermodynamic systems.
CO4: Construct chart and graphs.
CO5: Create publication-quality lab reports.
CO6: Enhance the presentation and team work skills.

TEXT/REFERENCE BOOKS

1. Cengel Y A and Bole M A, Thermodynamics: An Engineering Approach, 8th Edition, McGraw Hill (2014)
2. Nag P K, Engineering Thermodynamics, 6th Edition, McGraw Hill (2017)
3. Rayner Joel, Basic Engineering Thermodynamics, 5th Edition, Pearson (2008)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50	**Exam Duration: 2 Hrs**
Continuous evaluation	25 marks
End semester examination and Viva-voce	25 marks

20ME202T					Strength of Material					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of fundamental concepts of stresses and strains
- To obtain the analytical and graphical solutions of principle stress and strain
- To get acquainted with the theories on flexural stresses and bean deflections
- To get accustomed to the torsional forces in solid and hollow shafts

UNIT 1 SIMPLE STRESSES AND STRAINS **8 hrs.**

Elasticity and plasticity, Types of stresses and strains, Hooke's law, stress, strain diagram for mild steel, Working stress, Factor of safety, Lateral strain, Poisson's ratio and volumetric strain, Elastic moduli and the relationship between them, Bars of varying section, composite bars, Temperature stresses.

UNIT 2 PRINCIPAL STRESSES AND STRAINS, SHEAR FORCE AND BENDING MOMENT **12 Hrs.**

Principal stresses and strains: Stresses on an inclined section of a Bar under axial loading, compound stresses: normal and tangential stresses on an inclined plane for biaxial stresses. Two perpendicular normal stresses accompanied by a state of simple shear, Mohr's circle stresses- Principle stresses and strains- analytical and graphical solutions

Shear force and bending moment: Definition of beam, Types of beams, Concept of shear force and bending moment, S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads, Point of contra flexure, Relation between S.F., B.M and rate of loading at a section of a beam.

UNIT 3 FLEXURAL STRESSES, DEFLECTION OF BEAMS: **12 Hrs.**

Flexural stresses: Theory of simple bending, Assumptions, Derivation of bending equation, Neutral axis, Determination bending stresses, section modulus of rectangular and circular sections (Solid and Hollow), T, I, Angle, Channel sections, Design of simple beam sections.

Deflection of beams: Bending into a circular arc, slope, deflection and radius of curvature, Differential equation for the elastic line of a beam, Double integration and Macaulay's methods, Determination of slope and deflection for cantilever, overhanging and simply supported beams subjected to point loads, - U.D.L. Uniformly varying load.

UNIT 4 TORSION, COLUMNS & STRUTS **10 Hrs.**

Torsion: Torque, Derivation and use of torque equation, Shear stress diagram for solid and hollow circular shafts, Comparison between solid and hollow shaft with regard to their strength and weight, Power transmitted by shaft, Concept of mean and maximum torque.

Columns & struts: Buckling and Stability, Columns with Pinned ends, Columns with other support conditions, Limitations of Euler's Formula, Rankine's Formula, Columns with eccentric Axial Loads, Secant formula

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define the fundamental concepts of stresses and strains in one dimensional and two dimensional states
CO2: Sketch shear force and bending moment diagram for different types of beams with various loading conditions
CO3: Estimate the slope and deflection of beam subjected to various loading conditions
CO4: Interpret the bending and shear stresses in beams of different shapes
CO5: Estimate the power required for the shaft
CO6: Estimate the effective length of columns with different support conditions.

TEXT/REFERENCE BOOKS

1. James M Gere, Mechanics of Materials, Cengage publication (2014)
2. Beer and Johnston, Mechanics of Materials, Tata Mc Graw hill (2015)
3. R. C. Hibbeler, Mechanics of Materials, Prentice Hall, Pearson, India (2013)
4. S. S. Ratan, Strength of Materials, Tata Mc Graw hill (2011)
5. R.K.Rajput, Strength of materials, S.Chand & Co, New Delhi (2013)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 questions of 2 marks each 16 Marks
Part B/Question: 6 questions of 14 marks each 84 Marks

20ME202P					Strength of Material Lab.					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- To gain the fundamental knowledge of engineering in finding the strength of mechanical element subjected to various type of loadings.
- To Identify, formulate and solve the engineering problems exist in mechanical element under damage.
- To understand the failure behavior of structural element and impact of usage of material in various application.
- To learn about the physical aspect related to hardness, toughness, stress, impact, fatigue, tension, compression, torsion and fatigue.

LIST OF EXPERIMENTS

1. To study the stress-strain characteristics of mild steel, aluminum by conducting tensile test on UTM
2. To determine the Young's modulus of the material by conducting deflection test on a simply supported beam.
3. To determine the Modulus of rigidity by conducting Torsion test on Solid shaft
4. To find the Brinnell's hardness numbers of (a) Steel (b) Brass (c) Aluminum (d) Copper by conducting hardness test.
5. To find the Rockwell hardness numbers of (a) Steel (b) Brass (c) Aluminum (d) Copper by conducting hardness test.
6. To find compressive strength of wood and concrete by conducting compression test.
7. To find impact strength of (a) steel (b) aluminum by conducting izod impact test
8. To find impact strength of (a) steel (b) aluminum by conducting charpy impact test

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Illustrate the behaviour of material under impact condition
CO2: Understand the deflection of different sections at different loading conditions
CO3: Sketch stress- strain curve of ductile material under tensile loading
CO4: Compare compression strength between wood and concrete
CO5: Evaluate hardness of metals
CO6: Evaluate elastic constants using flexural and torsion test

TEXT/REFERENCE BOOKS

1. James M Gere, Mechanics of Materials, Cengage publication (2014)
2. Beer and Johnston, Mechanics of Materials, Tata Mc Graw hill (2015)
3. R. C. Hibbeler, Mechanics of Materials, Prentice Hall, Pearson, India (2013)
4. S. S. Ratan, Strength of Materials, Tata Mc Graw hill (2011)
5. R.K.Rajput, Strength of materials, S.Chand & Co, New Delhi (2013)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 100 **Exam Duration: 2 Hrs**

Viva (oral examination)	25 Marks
Lab exam	25 Marks

20ME203T					Mechanical Measurements and Metrology					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To introduce and familiarize the different industrial terminology for measurements systems and metrology.
- To familiarize different techniques for measurement of physical quantities such as pressure, force, torque etc.
- To introduce the concept of quality control and assurance and the role of measurement in it.
- To demonstrate the technique of automated inspection and machine vision for measurements.

UNIT 1 **10 Hrs.**

Fundamentals of measurement systems: Principal of measurements, metrology: introduction and types, methods of measurements, basic terminology of measurements. **Standard of measurement:** Roles of standards in measurement, material standards, types of standard, subdivision of standards, calibrations. **Transducers for Measurement:** Introduction to Transducers, its classification, Quality Attributes.

UNIT 2 **13 Hrs.**

Limits, Fits, Tolerance and Limit gauging: Principle of Interchangeability, selective assembly, Tolerances, allowance, Maximum and Minimum Metal Conditions, Fits, System of Limits and Fits, Hole basis and shaft basis systems, Design of Limit gauging: Taylor's Principle, Wear allowance in limit gauge, Plain Plug Gauges, Snap Gauges. **Measurements of Force, Torque, and Pressure:** Measurement of Force: platform balance, load cell, proving ring; Measurement of Torque: dynamometer; Pressure Measurement Scales, Method of Pressure Measurement, Ring Balance, Inverted Bell Manometer, Dead-weight Pressure Gauge, Measurement of Vacuum, High Pressure Measurement. **Measurements of Strain, Speed, and Temperature:** Techniques of Measurement of Strain, Strain Gauge Material, Backing or Carrier Materials, Adhesives, Protective Coatings, Bonding of Gauges. Different techniques of Measurement of speed such as tachometers & Speedometers. , Different techniques of temperature measurement such as thermometer.

UNIT 3 **12 Hrs.**

Linear and Angular metrology: Linear measurements instruments: verniers and micrometres; Angle measurement instruments: bevel protector, sine bar and centre, clinometers, collimator; Calibrations of the instruments, slip gauges. **Comparators:** Need for comparators, characteristics of comparators and its classifications. **Measurement of surface roughness and texture:** Significance of surface finish, terminology of surface texture, influencing factors for surface finish, symbolic representation of surface finish, surface roughness measurement techniques.

UNIT 4 **10 Hrs.**

Inspection and quality control: Introduction to Inspection and Quality Control, Quality Control and Quality Assurance, Statistical Quality Control, Total Quality Management, Six Sigma, Quality Standards.

Miscellaneous Metrology: Precision Instrumentation Based on Laser Principles, Coordinate Measuring Machines, Machine Tool Metrology, Automated Inspection, Machine Vision.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** the fundamentals of measuring systems, its terminology and roles of standards and Transducers
CO2: **Analyse** the measurement techniques for force, pressure, torque, strain, speed and temperature systems.
CO3: **Apply** the principles of limits, fits and tolerance for designing of industrial gauges.
CO4: **Apply** the concepts of Linear and angular metrology and to study the functioning of different comparators.
CO5: **Understand** the measurement system for roughness measurement and texture and advanced principle of automated inspection.
CO6: **Evaluate** the different aspects of quality assurance and control and the role of measurement in it.

TEXT/REFERENCE BOOKS

1. D S Kumar Mechanical Measurements and Control, Metropolian publisher.
2. R K Jain , Engineering Metrology, Khanna Publisher.
3. A K Sawhney, Mechanical Measurement and Instrumentation, Dhanpat Rai Publication.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME203P					Mechanical Measurements and Metrology – Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- To learn the working principles of different measuring devices and their precision.
- To familiarize with various types of measurements, methods, errors, and their limitations.
- To develop an ability to validly use measuring instruments.
- To appreciate the importance of measurements and metrology on the quality of a product/component.

List of Experiments:

1. To measure the various dimensions of the given work piece by various measuring Instruments.
2. Introduction to generalized measurement system and Terminology.
3. To study the working of following instruments and Analysis of environmental parameters at different locations.
4. Feature recognition using optical method, selection and counting.
5. To study and calibrate the precision measuring instruments like Vernier calliper, Micrometre, and Dial gauge.
6. To get acquainted with sine bar.
7. Surface analysis of various manufacturing processes.
8. To measure the fundamental dimensions of a gear using contour (profile) projector.
9. To study different types of the comparators.
10. To demonstrate different types of Limit Gauges.
11. Add Screw and Gear parameter measurement

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the working principles and operations of various instruments.
CO2 - Analyse the effect of different parameters on the measurements and methodologies.
CO3 - Demonstrate the significance of different instruments for different measurements.
CO4 - Judge the uses of appropriate techniques for different measurement applications in practical life.
CO5 - Appraise the limitations of each measurement technique and methodologies followed.
CO6 – Explain the qualitative significance of the quantitative results obtained.

TEXT/REFERENCE BOOKS

1. Lab Manual, PDPU
2. Alan S. Morris, Measurement and Instrumentation Principles, Elsevier
3. D S Kumar Mechanical Measurements and Control, Metropolian publisher.
4. R K Jain , Engineering Metrology, Khanna Publisher.
5. A K Sawhney, Mechanical Measurement and Instrumentation, Dhanpat Rai Publication.

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50

Viva (oral examination)	25 Marks
Lab exam	25 Marks

20HS201P					Communication Skills – II (Semester – III/IV) (Second Year)					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	0	2 hours per week	--	--	--	50	50	100

COURSE OBJECTIVES

- To understand communication and its process and effect on giving and receiving information.
- To learn and apply communication skills in different public and interpersonal contexts.
- To develop analytical, research, and organizational skills through communication skills for a fulfilling career.

UNIT 1 **7 hrs**

- Technical Writing
  - ✓ Report Writing
  - ✓ Creating Lab Journals and Manuals
- Portfolio of Critical Writing and Creative Writing
  - ✓ Essay, Story-writing, etc.

UNIT 2 **7 hrs**

- Summarizing
- Writing Reviews (Books/Articles/Movies/websites)
- Reading Skills (Advanced)

UNIT 3 **7 hrs**

- Digital Literacy
  - ✓ Emails
  - ✓ Creating e-content
  - ✓ Editing and proofreading online
  - ✓ Using grammar and spell check software
  - ✓ Using plagiarism checkers

UNIT 4 **9 hrs**

- Group Discussion
- Resume Writing
- Interview Skills

Max. 30 hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO 1 Apply current technology for effective communication leading to better dissemination of knowledge and expertise.
CO 2 Demonstrate relevant knowledge of communication skills in different settings to cater to different purposes and audiences.
CO 3 A sound understanding of communication theory, practice and application to optimize career opportunities.
CO 4 Dynamic communication skills to build and maintain robust and effective professional relationships.
CO5 Augmented communication skills to prepare and present messages, reports and documents in intent and to integrate different sources of information and knowledge.
CO 6 Monitoring and critical reflection on communication skills for the adoption of appropriate strategy required in achieving the desired outcomes.

TEXT/REFERENCE BOOKS

1. Harmer, Jeremy. The Practice of English Language Teaching. Harlow: Pearson Longman, 2007.
2. Kaul, Asha. Business Communication. Delhi: Prentice-Hall of India, 2006.
3. Maley, A. 'Literature in the Language Classroom', The Cambridge Guide to Teaching ESOL, Cambridge University Press, 2001.
4. Richards, Jack C., and Willy A. Renandya, eds. Methodology in Language Teaching: An Anthology of Current Practice. Cambridge University Press, 2002.
5. Sharma, Sangeeta and Binod Mishra. Communication Skills for Engineers and Scientists. New Delhi: PHI Learning Pvt. Ltd., 2009.

Assessment Tool	Marks	Assignments
Lab Work	50	Essay/Journal Writing – 10; Report Writing – 10; Creating e-content – 10; Blog Writing – 10; Review Writing - 10
Lab Exam/Viva	50	Mock Interview – 15; Group Discussion – 15; Cover Letter/Curriculum - 20

Course Structure of B. Tech. in Mechanical Engineering

COURSE STRUCTURE FOR B.TECH. SECOND YEAR (Mechanical Engineering)

SEMESTER IV (Subjects)				B.TECH. SECOND YEAR (Mechanical Engineering)											
Sr. No.	Category Code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
				L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
									CE	MS	ES	CE	ES	
1	PCC	20ME205T	Fluid Mechanics	3	0	0	3	3	25	25	50	-	-	100
2	PCC	20ME205P	Fluid Mechanics - Lab.	0	0	2	1	2	-	-	-	25	25	50
3	PCC	20ME206T	Design & Kinematics of Machines	3	0	0	3	3	25	25	50	-	-	100
4	PCC	20ME206P	Design & Kinematics of Machines - Lab.	0	0	2	1	2	-	-	-	25	25	50
5	PCC	20ME216T	Engineering Metallurgy	3	0	0	3	3	25	25	50	-	-	100
6	PCC	20ME216P	Engineering Metallurgy - Lab.	0	0	2	1	2	-	-	-	25	25	50
7	PCE	20MEXXXT	Professional Core Elective - I	3	0	0	3	3	25	25	50	-	-	100
8	OE	20MEXXXT	Open Elective - II	3	0	0	3	3	25	25	50	-	-	100
9	IND	20IF201T	Industry 4.0	2	0	0	2	2	25	25	50	-	-	100
10	IND	20IF201P	Industry 4.0 - Lab	0	0	2	1	2	-	-	-	50	50	100
11	PCC	20ME208P	Mechanical Drawing Laboratory	0	0	2	1	2	-	-	-	-	-	-
12	Project	20TP210	Industrial Orientation (3 weeks-summer break)	0	0	0	1	0	-	-	-	-	-	-
			Total	**17**	**0**	**10**	**23**	**27**						

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

Professional Core Elective – I:

Course Code	Course Name		Course Code	Course Name
20ME207T	Control System Engineering		20ME210T	Introduction to Composite Materials
20ME209T	Engineering Economics		20ME211T	Mechanics of Materials

Open Elective – II:

Course Code	Course Name		Course Code	Course Name
20ME212T	Entrepreneurship & Business Plan Formulation		20ME214T	Materials and Manufacturing
20ME213T	Renewable Energy		20ME215T	Rapid Prototyping

20ME205T					Fluid Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop the basic understanding of fluid kinematics and dynamics
- To develop analytical skills to deal with various types of fluid flow problems
- To impart knowledge on importance of flow phenomena and its applications to various fluid flow systems.

UNIT 1 FLUID STATIC AND KINEMATICS **10 Hrs.**

Fluid Statics: Properties of fluids, Archimedes Principle , Buoyancy and stability of floating and submerged bodies, Meta-centric height. Kinematics: Types of flow, concept of continuum, pressure and stress tensor. Fluid Kinematics: Lagrangian and Eulerian description, streamline, streakline and pathline, acceleration of a fluid element, continuity equation, stream-function, rotation and angular deformation, irrotational flow, velocity potential.

UNIT 2 FLUID DYNAMICS **13 Hrs.**

Integral Flow Analysis: Reynolds transport theorem, conservation of mass/continuity equation, conservation of linear and angular momentum for a control volume in inertial and accelerating reference frames, energy equation, Bernoulli's equation, engineering applications. Differential Analysis of Flow: Stokes law of viscosity and Navier-Stokes equations.

UNIT 3 VISCOUS FLOW **11 Hrs.**

Reynolds experiment: laminar and turbulent flow. plane Poiseuille flow, Couette flow, Hagen-Poiseuille flow; Friction factor and Moody's diagram, losses in pipes, pipe fittings pipe networks.

UNIT 4 DIMENSIONAL ANALYSIS AND BOUNDARY-LAYER THEORY **11 Hrs.**

Dimensional Analysis and Similitude: Buckingham-PI theorem, nondimensional parameters, problem-solving using non-dimensionalization; Reynolds number and Mach number similarity.

Boundary-Layer Theory: Boundary layer thicknesses, Characteristics of Boundary Layer, Boundary Layer Equations, Momentum Integral Equation and its solution. Boundary layer separation. Flow around circular cylinder and aerofoil and development of lift on aerofoil.

Max. 45 Hrs.

COURSE OUTCOMES:

On completion of the course, student will be able to

CO1 - Recognize type of fluid flow and flow pattern for internal and external flows.
CO2 - Evaluate transport properties of fluid for internal and external flows.
CO3 - Apply conservation principles of mass, linear momentum, and energy to fluid flow systems to determine flow quantities and energy losses in fluid flow systems.
CO4 - Evaluate and arrive at reasonable approximations for a fluid flow problem where flow is governed by the continuity equation and Navier-Stokes equation
CO5 - Design simple pipe systems to deliver fluids under specified conditions.
CO6 - Apply dimensional analysis to predict physical parameters that influence the flow in fluid mechanics.

TEXT/REFERENCE BOOKS

1. F. White, Fluid Mechanics, Tata-McGraw Hill publishers, 2011.
2. Y. A. Cengel and J. M. Cimbala, Fluid Mechanics Fundamentals and Applications, Tata-McGraw Hill Publishers, 2015.
3. R. Fox and A. McDonald, Introduction to Fluid Mechanics, John Wiley Publishers, 2011.
4. V. Streeter and Benjamin, Fluid Mechanics: First SI-Metric, McGraw-Hill, Auckland 2001.
5. Currie, I.G., Fundamental Mechanics of Fluids, 4th Edition, CRC Press, 2012.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

10 Questions each of 10 marks from above units with appropriate marks distribution among designed Course Outcomes (COs) 100 Marks

20ME205P					Fluid Mechanics Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	02	-	-	-	25	25	50

COURSE OBJECTIVES

- To impart knowledge on construction and working principle of various flow measuring devices.
- To impart practical exposure on the performance evaluation methods of various flow measuring equipment and energy losses fluid flow through pipe.
- To develop understanding on experimental data analysis, technical report writing and work in teams.

LIST OF EXPERIMENTS:

Experiment 1: Verification of Bernoulli's principle

Experiment 2: Discharge coefficient of Venturimeter

Experiment 3: Discharge coefficient of Orificemeter

Experiment 4: Calibration of Rotameter

Experiment 5: Reynolds apparatus

Experiment 6: Flow measurement with Pitot tube

Experiment 7: Friction losses in circular pipe

Experiment 8: Effect of pipe diameter and length on friction losses in pipe

Experiment 9: Measurement of viscosity

COURSE OUTCOMES

On completion of the course, student will be able to

CO1- Apply mass and energy conservation principles to fluid flow systems to estimate energy losses.
CO2 - Evaluate the coefficient of discharge and calibration of flow measuring devices.
CO3 - Identify flow patterns and flow types for internal flow systems.
CO4 - Evaluate, compare and contrast experimental results of major and minor losses for internal flow systems with theoretical trends, and to attribute observed discrepancies to various errors.
CO5 - Design and conduct experiments, analyze and interpret data for fluid flow systems.
CO6 - Develop the ability for team work

TEXT/REFERENCE BOOKS

1. F. White, Fluid Mechanics, Tata-McGraw Hill publishers, 2011.
2. Y. A. Cengel and J. M. Cimbala, Fluid Mechanics Fundamentals and Applications, Tata-McGraw Hill Publishers, 2015.
3. R. Fox and A. McDonald, Introduction to Fluid Mechanics, John Wiley Publishers, 2011.
4. V. Streeter and Benjamin, Fluid Mechanics: First SI-Metric, McGraw-Hill, Auckland 2001.
5. Currie, I.G., Fundamental Mechanics of Fluids, 4th Edition, CRC Press, 2012.

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs**

Part A: Experiment 20 Marks

Part B: Viva Voce 30 Marks

20ME206T					Design and Kinematics of Machines					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn the theory of design and kinematics
- To design rivets, welded joints, shafts, couplings and springs
- To calculate position, velocity and acceleration of various mechanism through analytical method

UNIT 1 Introduction to Design, Kinetics and Kinematics **10 Hrs.**

Introduction: Design procedure, coding of materials, factors of safety, standards, aesthetics, ergonomics, design aspects in selection of materials and in manufacturing, fundamentals of kinematics and mechanisms, kinematic link, types, kinematic pair, types of motions, kinematic pairs and chain, types of joints, mechanism, machine, degree of freedom (mobility), inversions of simple mechanisms, Grashoff's law

Role of Design in Industry 4.0: Concurrent Engineering, CAE, CAD, simulation, various computation tools used to design, modelling and analysis

UNIT 2 Design of Joints and Spring **12 Hrs.**

Design against static loading: Design of Cotter joint and Knuckle joint

Design Riveted and Welded Joint: Terminology of a riveted joint, types of rivets and riveted joints, Design of a riveted joint, Joint Efficiency, Eccentrically loaded riveted joint, Types of welded joints, Stresses in welded joints and design of it.

Design of Mechanical Springs: Types of springs, Materials for Springs, Stresses, deflection and buckling of helical springs, Helical Springs of non-circular cross-sections, Helical Tension spring, Energy storage capacity, Helical torsion springs, Co-axial springs, leaf springs

UNIT 3 Design of Shafts, Keys and Couplings **13 Hrs.**

Design of Shafts, Keys and Couplings: Shaft Material, Design of solid and hollow shafts for strength and rigidity, Design of shafts for combined bending and axial loads, Types of couplings, Design of flange coupling, Design of keys

UNIT 4 Kinematic Synthesis **10 Hrs.**

Synthesis of Linkages: Type, number and dimensional synthesis. Path, function and motion generation (Body guidance). Precision Positions, Chebyshev spacing, Crank Rocker mechanisms, Analytical synthesis: Derivation of Freudenstein's equation, Three-position function generation using Freudenstein's equation.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** the fundamentals of design and the theory of kinematics and mechanisms.
CO2 - **Explain** the various mechanical components such as rivets, welded joints, shafts, couplings, springs and synthesis of mechanisms.
CO3- **Apply** the various mechanical design and kinematics principles to design various mechanical components.
CO4- **Analyse** the position of machines and their components.
CO5- **Estimate** the dimensions and position of various mechanical components.
CO6- **Formulate and design** rivets, welded joints, shafts, couplings, springs and various mechanisms.

TEXT/REFERENCE BOOKS

1. V. Bhandari, Machine Design, Tata-McGraw Hill Publishers.
2. J. Shigley, C. Mischke, R. Budynas, Mechanical Engineering Design, Tata-McGraw Hill Publishers.
3. S. S. Ratan, Theory of Machines, Tata Mc Graw-Hill publications, New Delhi
4. R. Norton, Machine Design: An Integrated Approach, Pearson Education Publishers.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks

20ME206P					Design and Kinematics of Machines Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	--	2	1	--	--	--	50	50	100

COURSE OBJECTIVES

- To learn the theory of design and kinematics
- To design lever, cams and power screws
- To draw and calculate position, velocity and acceleration of various mechanism through graphical and analytical method

Experiment No.	Title	Hrs.
1	Design and Drawing of Power screw	4
2	Design and Drawing of Lever	2
3	Design and analysis of Cam Profile through Follower displacement diagrams	6
4	Analysis and drawing of Simple Mechanisms by relative velocity method	2
5	Analysis and drawing of Simple Mechanisms by instantaneous center method	2
6	Drawing of Klein's construction for velocity calculation	2
7	Analysis and drawing Simple Mechanisms by Acceleration diagram and Coriolis component of acceleration,	4
8	Graphical synthesis: Two and three position synthesis using relative pole method	2
9	Graphical synthesis: inversion method for single slider crank and four bar mechanism,	2
10	Three position motion synthesis of four bar Mechanism.	2
11	Development of prototype of Simple Mechanism	2

Max. 30 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** the fundamentals of design and the theory of kinematics and mechanisms.
CO2 - **Explain** the various mechanical components such as lever, power screws, cams and velocity-accelerations of mechanisms and synthesis of mechanisms.
CO3- **Apply** the various mechanical design and kinematics principles to design various mechanical components.
CO4- **Analyse** the design of motion of machines and their components.
CO5- **Estimate** the dimensions, velocity and acceleration of various mechanical components.
CO6- **Formulate and design** cams, power screws and various mechanisms.

TEXT/REFERENCE BOOKS

1. V. Bhandari, Machine Design, Tata-McGraw Hill Publishers.
2. J. Shigley, C. Mischke, R. Budynas, Mechanical Engineering Design, Tata-McGraw Hill Publishers.
3. S. S. Ratan, Theory of Machines, Tata Mc Graw-Hill publications, New Delhi
4. R. Norton, Machine Design: An Integrated Approach, Pearson Education Publishers.

LAB EXAMINATION PATTERN

Max. Marks: 100	**Exam duration: 2 Hrs**
Continuous Evaluation	50 Marks
Lab Exam	50 Marks

20ME216T					Engineering Metallurgy					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To know the importance of metallurgy in manufacturing.
- To learn different types of mechanical properties and their evaluations.
- To study microstructural features in metallic materials.
- To acquire knowledge of different types of metallic materials.

UNIT 1 Testing of metals **9 Hrs.**

Concept of stress and strain, strength, elasticity, plasticity, stiffness, resilience, toughness, malleability, ductility, and brittleness. Mechanical testing: tensile, compression, hardness, fatigue, wear, creep, impact. NDT: visual inspection, dye penetration test, radiography, edy current, ultrasonic. DBT curve. ASTM standards for mechanical testing.

UNIT 2 Structure Property Relation **10 Hrs.**

Engineering metals and alloys, Elastic and plastic deformation, deformation in a single crystal and polycrystalline metal, Critical resolved shear stress, plastic deformation mechanisms-slip and twin, effect of defects on deformation mechanism, work hardening, fracture in metals, changes in properties due to deformation, re-crystallization, cold working and hard working. Metallography: Optical and electron microscopy (OM, SEM, EBSD, TEM, XRD).

UNIT 3 Ferrous and Non-Ferrous materials **10 Hrs.**

Ferrous metals and Designation: Wrought and cast components, allotropy of iron, iron-carbon diagram, plain carbon steels, limitations of plain carbon steel, and advantages of alloy steels. Effect of alloying elements on mechanical properties of steel, alloy steels, tool steels, stainless steels, cast irons. Designation of steels and cast iron. Corrosion in metallic materials. Non- ferrous metals and alloys: Al, Cu, Mg, Ti, and Ni.

UNIT 4 Heat treatment and advanced materials **10 Hrs.**

Effect of non- equilibrium cooling on microstructure and properties of steel, TTT diagram for 0.8% carbon steel, Isothermal treatments, continuous cooling transformation curves, critical cooling rate & heat treatments like annealing, normalizing, hardening and tempering. Hardenability of steels, jominey end quench test, surface hardening treatment scarburizing. Nitriding, carbonitriding, tufftride, sursulf, induction hardening and flame hardening. Advanced materials: types and properties of composite materials, high temperature materials, cryogenic materials, shape memory alloy.

Total 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 Define mechanical properties of materials.
CO2: Understand fundamental understanding of Mechanical, Metallurgical and NDT testing.
CO3: Distinguish Ferrous and non-ferrous materials.
CO4: Evaluate relation between structure and properties.
CO5: Analyse importance of the heat treatment processes.
CO6: Remember ASTM Standards and its relevance for mechanical testing.

TEXT/REFERENCE BOOKS

1. William D Callister, Jr., Materials Science and Engineering, Wiley India (P) Ltd.
2. F.C. Compbell, Elements of Metallurgy and Engineering Alloys, ASM International, Ohio.
3. George Dieter, Mechanical metallurgy, McGraw-Hill.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 3 Questions from each unit - each carrying 5 marks 60 Marks
Part B/Question: 1 Question from each unit- each carrying 10 marks 40 Marks

20ME216P					Engineering Metallurgy Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- To learn the practical significance of different types of mechanical testing of materials and their interpretation
- To develop an understanding on the methods followed for visualizing the microstructures and constituent phases of the materials, their analysis and their impact on the observed properties
- To study the materials and their properties while correlating their microstructures and defects with different types of manufacturing processes and their parameters

UNIT 1 Mechanical Testing of Materials

Familiarize with ASTM Standards - E6, E8, E21, E23, E92, E190, E290, and G65

1. Generate both Engineering and True Stress Vs Strain curves and measure the tensile properties of the materials including modulus of resilience, and interpret the importance of each property
2. Correlate the tensile strength with hardness data and understand the variability of material properties.
3. Hardness measurements - Micro and Macro, including Knoop hardness test, and study the variations in micro and macro hardness of the welded steel samples using Vickers hardness test.
4. Correlate the Impact energy to the temperate and understand the importance of Ductile-to-Brittle Transition behaviour of the materials
5. Develop S-N curves for steels and determine their fatigue life & fatigue strength

UNIT 2 Metallography and Property Correlation

Familiarize with ASTM Standards – E340 and E527

1. Over view of Metallography procedures, and Metallurgical microscopes their construction, applications and limitations
2. Overview of Scanning Electron Microscopy and its advantages over optical microscopy
3. Metallographic examination of steels and alloys, their phase analysis, application of lever rule in phase analysis and correlating to the phase diagrams
4. Number Familiarize with ASTM Grain size chart and determine the ASTM Grain Size
5. Metallography of weldments - Macro and Microstructures
6. Metallographic examination of Ferrous Metals including Stainless Steels
7. Metallographic examination of Non Ferrous Metals - Aluminium and Copper
8. Fractrographay of different materials (Tensile, Brittle, Fatigue and Creep)
9. Wear Testing of Metallic Samples (ASTM G65)
10. Super plasticity of metallic materials and elevated temperature tensile tests of metallic materials (ASTM E 21)
11. In-situ NDT tool for health assessment, and practical demonstration of various NDT methods
12. Effect of heat treatments on microstructures

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the working principles and operations of various instruments.
CO2 - Analyse the effect of different parameters on the measurements and methodologies.
CO3 - Demonstrate the significance of different instruments for different measurements.
CO4 - Judge the uses of different techniques for different applications in practical life.
CO5 - Appraise the limitations of each technique and methodologies followed.
CO6 - Case study the materials and correlate to their properties

TEXT/REFERENCE BOOKS

1. Donald C. Zipperian, METALLOGRAPHIC HANDBOOK, PACE Technologies, USA
2. William D. Callister, Jr. Materials Science and Engineering an Introduction
3. Various ASTM standards and Lab Manual - PDPU

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz	10 Marks
Experiment	15 Marks

20ME207T					Control System Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the use of transfer function models for analysis physical systems.
- To formulate the mathematical model and acquire the steady and transient response of systems.
- To obtain the open and closed loop Root locus and frequency responses of systems.
- To introduce stability analysis and design of compensators.

UNIT 1 INTRODUCTION TO CONTROL SYSTEM **10 Hrs.**

Introduction to control systems, Closed and open loop control frameworks. Examples of several closed loop and open loop control systems. Review of Laplace transformation, Inverse Laplace transformation. MATLAB implementation of Laplace transformation.

UNIT 2 MATHEMATICAL MODELING OF MECHANICAL SYSTEMS **12 Hrs.**

Formulation of mathematical model of mechanical systems, Transfer function and Impulse response function, Introduction of State-Space representation, Transient and steady state response analysis of 1^{st} and 2^{nd} order systems, Routh's stability criterion. MATLAB based formulation of transfer functions.

UNIT 3 ROOT LOCUS AND FREQUENCY RESPONSE ANALYSIS **12 Hrs.**

Root locus, General rules for constructing root locus, design by root locus- Lead, Lag compensators, Bode plot, Nyquist criterion and plots, Stability analysis, Control system design by frequency response – Lead, lag compensator, MATLAB implementation for drawing Root locus and Bode diagrams.

UNIT 4 PID CONTROLS AND STATE SPACE REPRESENTATION **11 Hrs.**

Ziegler-Nichols method, Rules for tuning PID controllers, Effect of PID control action on mechanical systems, Zeros and Pole placements, State-Space representation of transfer function, Controllability and Observability. MATLAB implementation for formulating state space modelling.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Understand** the basics of control systems using transfer function.
CO2 - **Establish** the mathematical model of a physical mechanical system.
CO3 - **Obtain** the transient and steady state response analysis of 1st and 2nd order systems.
CO4 - **Construct** the Root locus and **Design** the lead and lag compensators using it.
CO5 - **Utilize** the frequency response to **Obtain** the Bode diagram and access the stability of the system.
CO6 - **Design** the PID controller and understand the basics of state space representation.

TEXT/REFERENCE BOOKS

1. Ogata, Katsuhiko, and Yanjuan Yang. Modern control engineering. Vol. 5. Upper Saddle River, NJ: Prentice hall, 2010.
2. Nise, Norman S. CONTROL SYSTEMS ENGINEERING, (With CD). John Wiley & Sons, 2007.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 10 Questions from unit I, II	50 Marks
Part B/Question: 10 Questions from Unit III, IV	50 Mark

20ME209T					Engineering Economics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Understand concepts; principles which govern the function of firm/organisation
- Understand the dimensions of evaluating engineering alternative
- Understand the time value of money ; interest rate & its implication
- Analyses cash flow series using present worth ; annual equivalent worth &rate of returns methods of assessment
- Develop cash flow that include effect of taxes; inflation; depreciation ;loan payment & its interest

UNIT 1 Concept of Economics & Production at firm level **10 Hrs.**

Introduction to economics; definition; nature & scope. Theory ; law of demand & supply ; equilibrium of D& S. Different elasticity concepts.Flow in the economy Theory of production & factors of production (Land; labour; capital & entrepreneurship) Laws of variable proportion & laws of economics of scale Cost; meaning-short run; long run cost; Fixed –variable; total cost. Concept of average ; marginal & opportunity cost

UNIT 2 Basics of Engineering Economics **10 Hrs.**

Elementary economic analysis-material; process selection. Process planning & modification. Time Value of Money-interest formula & its application. Concept of Present worth; future worth; sinking fund & capital recovery. Basics of comparisons of alternatives.

UNIT 3 Techniques & Analysis of Engineering Economics **10 Hrs.**

Working ;comparisons & application of present worth method; future worth method; annual equivalent method & rate of return method

UNIT 4 Decision Making using Engineering Economics in an organisation. **10 Hrs.**

Replacement; maintenance analysis. Assessing the economic life of assets. Concept & methods of depreciation & its application. Inflation adjusted economic decisions. Make OR buy analysis using cost analysis; economic analysis & break even analysis

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Students will understand the frame work function of firm & optimising the production cost
CO2 -Students will define & provide the examples of time value of money
CO3 – Students will solve economic problems involving comparison & selecting alternative by using variety of analytical techniques
CO4 – Students will demonstrate the effect of depreciation; taxes; inflation & loan on changes in Engineering economic analysis
CO5 – Students will apply knowledge of engineering economics in evaluating projects from Financial perspective
CO6 – Students will be able to participate in decision making process of technology selection & Other business decisions

TEXT/REFERENCE BOOKS

1. Panneerselvam, R. Engineering economics. PHI Learning Pvt. Ltd., 2013
2. Gupta, G., Managerial Economics, Tata McGraw-Hill
3. Pindyck and Rubinfeld, Microeconomics, Pearson publication

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: <4 Q * 5 marks each 20 Marks
Part B/Question: <8 Q * 10 marks each 80 Marks

20ME210T					Introduction to Composite Materials					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	50	100	25	--	--	100

COURSE OBJECTIVES

- To learn the concept of composites, types and properties.
- To learn various fabrication methods of composites.
- To learn applications of composites.

UNIT 1 Introduction **12 Hrs.**

Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Types of matrix, Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential

UNIT 2 Composite Classification **10 Hrs.**

Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites, Isotropic, Anisotropic, symmetric, Unsymmetric laminates

UNIT 3 Fabrication Methods **15 Hrs.**

Hand Lay-up, Prepreg Lay-up, Bag Molding, Autoclave Processing, Compression Molding, Resin Transfer Molding, Vacuum Assisted Resin Transfer Molding, Pultrusion, Filament Winding,

UNIT 4 Advanced application of Composites **5 Hrs.**

Aircraft: Composite Components in Aircraft, Specific Aspects of Structural Resistance, Large Carriers, Regional Jets, Light Aircraft, Fighter Aircraft, Turbine Blades in Composites, Helicopters, Composite Materials and the Manufacturing of Automobiles, Composites in Naval Construction, Sports and Recreation

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Recall** the fundamental of metals and composites.
CO2 – **Explain** the fibres and matrix and its properties.
CO3 – **Demonstrate** different advanced application of composites
CO4 – **Apply** the various fabrication techniques to manufacture composites.
CO5 – **Classify** the different types of composites.
CO6 – **Decide** specific type of composite applicable to different applications.

TEXT/REFERENCE BOOKS

1. Gay, Daniel. Composite materials: design and applications. CRC press, 2014.
2. Materials characterization, Vol. 10, ASM hand book
3. Bhargava, A. K. Engineering materials: polymers, ceramics and composites. PHI Learning Pvt. Ltd., 2012.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks

20ME211T					Mechanics of Materials					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand stress and development of strain energy in mechanical components.
- To determine the failure criteria of machine element subjected to various loading.
- To study the theory to find the stresses in curved bars, beams, discs and spring element.

UNIT 1 STRESS TENSOR AND STRAIN ENERGY **10 Hrs.**

Stress and strain tensor, principal stress and strain, Mohr's circle representation of tri-axial stresses and strains. Strain Energy & Impact Loading: Definitions, expressions for strain energy stored in a body when load is applied (i) gradually, (ii) suddenly and (iii) with impact, strain energy of beams in bending, beam deflections, strain energy of shafts in twisting, energy methods in determining spring deflection, Castigliano's theorem.

UNIT 2 THEORIES OF FAILURE AND PRESSURE VESSELS **12 Hrs.**

Theories of Elastic Failures: Modes of failure, the necessity and significance of a failure theory, statement of various theories of failure and their application, graphical representation, comparison and limitations of various failure theories, safety factors. Pressure Vessels: Hoop & Longitudinal stresses & strains in thin cylindrical & spherical vessels under internal pressure, Radial & hoop stresses and strains in thick vessels, Lame's equation, compound cylinders and spherical shells subjected to internal fluid pressure only, hub shrunk on solid shaft.

UNIT 3 BEAM AND CURVED BARS **12 Hrs.**

Beams: Fixed beams, continuous beams and overhanging beams, moment-area method, Macaulay's method, moment distribution method. Curved Bars: Stresses in bars of large initial curvature, Winkler-Bach theory, location of neutral axis, distribution of stresses across sections having rectangular, circular and trapezoidal shapes.

UNIT 4 SPRINGS AND ROTATING DISCS **12 Hrs.**

Springs: Stresses in closed coiled helical springs, Stresses in open coiled helical springs subjected to axial loads and twisting couples, leaf springs, flat spiral springs, concentric springs. Rotating discs: Stresses and strains in- rotating rims or rings of uniform thickness (ii) rotating thin solid and hollow discs of uniform thickness, stresses and strains in rotating thin disc of uniform strength, stresses and strains in rotating solid and hollow cylinders.

Max. 46 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** the concept of stress and strain.
CO2 - **Explain** the concept of strain energy in beam, bars and spring element.
CO3 - **Apply** failure criteria to determine the geometrical parameters mechanical components.
CO4 - **Classify** the stresses developed in different beams, curved bars and pressure vessels.
CO5 - **Evaluate** the stresses in mechanical component subjected to different types of load.
CO6 – **Formulate** a real life problem such as spring, crane hook, cylinders to determine stresses.

TEXT/REFERENCE BOOKS

1. Beer P F and Johnston (Jr) E R, "Mechanics of Materials", McGraw Hill Education, 7th edition, 2015.
2. G H Ryder, "Strength of Materials", ELBS, 3rd edition, 1969
3. Timoshenko, S.P., and Gere, J.M., "Mechanics of Materials", 2nd Ed., CBS Publishers,

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A-4 Questions: 10 Marks each 40 Marks
Part B-4 Questions: 15 Marks each 60 Marks

20ME212T					Entrepreneurship & Business Plan Formulation					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Develops motivation, reinforces entrepreneurial traits and the spirit of enterprise;
- Understand the frame work of opportunity identification & business plan
- Facilitates decision making process for setting-up of a new enterprise;
- Facilitates successful and profitable operation of the enterprise
- Making students aware of resources available in eco system for enterprise creation

UNIT 1 Entrepreneurial Mind Set; Approaches & Mapping Business opportunities **12 Hrs.**

Entrepreneurial Mind set; Assessing-Interpretation & developing entrepreneurial competencies; entrepreneurial games. Ideas V/S opportunity; Approaches for identification of new ideas; sources of innovative ideas; creative thinking & process with exercises; Types innovation its process; mapping ideas as opportunity –pre-feasibility analysis; developing project profiles

UNIT 2 Frame work for business plan preparation **12 Hrs.**

Market & demand analysis; situational analysis; primary & secondary survey; demand forecasting & market planning Technical Analysis; manufacturing process/technology; Material inputs & utilities; plant capacity; location & site selection; machinery & structure choices & selection; project charts& layout; schedule of project implementation & developing alternatives Financial Estimates & Projections; Cost of projects; means of finance; profitability projection; working capital assessment & financing; project cash flow preparation Business plan selection; investment criteria; risk analysis; developing financing options & tie up

UNIT 3 Options & Search for Entrepreneurial Capital **8Hrs.**

Financing of business & options; bank finance; venture capital; private equity; innovative funding; seed capita; Government policy packages

UNIT 4 Entrepreneurship Eco system & Practices **8 Hrs.**

Forms of ownership; IPR; basic laws & processes related to start up; understanding organization in the eco system for promotion of start-up firms; discussion with different types of entrepreneurs & organizations

Max. <40> Hrs.

COURSE OUTCOMES

On completion of the course, student will be;
AWARE, SENSITIVE AND DEVELOP THEIR COMPETNECIES OF

CO1. Entrepreneurial Orientation
CO2. Sensing the Opportunities
CO3. Assessment & Selection of Opportunities
CO4. Purposeful Innovation
CO5. Formulating & Structuring Innovative Businesses
CO6 Acquire information wrt to support for enterprise creation

TEXT/REFERENCE BOOKS

1. Kumar, Arya. Entrepreneurship: Creating and leading an entrepreneurial organization. Pearson Education India, 2012.
2. Kuratko, Donald F., and T. V. Rao. "Entrepreneurship: A South-Asian Perspective." Cengage Learning (2012).
3. Zimmerer, Thomas W., and Norman M. Scarboroug. Essentials of entrepreneurship and small business management. Prentice-Hall, 2005.
4. Chandra, Prasanna. Projects 7/E. Tata McGraw-Hill Education, 2009.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 4Q * 4	16 Marks
Part B/Question: 6Q * 6	36 Marks
Business plan Preparation & Presentation	50 Marks

20ME213T					Renewable Energy					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVE

- The students are expected to identify the new methodologies / technologies for effective utilization of renewable energy sources

UNIT 1 Solar Energy (12)

introduction to different energy sources and importance of renewable energy sources, Solar Radiation, Measurements of Solar Radiation, Flat Plate And Concentrating Collectors, Solar Direct Thermal Applications, Solar Thermal Power Generation, Fundamentals of Solar Photo Voltaic Conversion, Solar Cells, Solar PV Power Generation, Solar PV Applications.

UNIT 2 Wind and Ocean Energy (8)

Wind energy: Wind Energy Estimation, Types of Wind Energy Systems, Performance, Site Selection, Details of Wind Turbine Generator, **Ocean Energy**: Ocean Thermal Energy Conversion (OTEC), Principle of operation, development of OTEC plants, Tidal and wave energy, Potential and conversion techniques, mini-hydel power plants.

UNIT 3 Biomass, Geothermal and other renewable energy (12)

Biomass: Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking. **Geothermal Energy:** Resources, types of wells, methods of harnessing the energy, scope in India. **Fuel cell:** Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells **Hydrogen Energy** - Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles

UNIT 4 Energy conservation (8)

Energy conservation and its importance. Energy Conservation Acts: 2001, 2010, Electricity act 2003, Integrated energy policy, Schemes under EC act 2001, Principles of energy conservation, the different energy conservation appliances, energy efficiency in different utilities, general energy saving tips

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the Need, importance and scope of non-conventional and alternate energy resources.
CO2: Understand role significance of solar energy
CO3: Provide importance of Wind Energy
CO4: Understand the role of ocean energy in the Energy Generation.
CO5: Get the utilization of Biogas plants and geothermal energy.
CO6: Understand the concept of energy Conservation.

TEXT/REFERENCE BOOKS

1. Sukhatme S P and Nayak J K, Solar Energy, 4th edition, Tata McGraw Hill (2017)
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, 3rd edition, Oxford University Press, U.K., (2012)
3. John Twidell and Tony Weir, Renewable Energy Resources, 3rd edition, Routledge Publisher (2015).

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME214T					Materials and Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To know materials with their applications in manufacturing.
- To know different properties of various materials.
- To understand the importance of manufacturing techniques for modern day industry.
- To comprehend the development of modern and upcoming manufacturing technologies.

UNIT 1 Materials and their applications **10 Hrs.**

Metallic materials, Non-metallic materials, composites, super alloys, shape memory alloys, superplastic alloy, SMART materials. Bio-implant materials and their properties.

UNIT 2 Material properties **12 Hrs.**

Mechanical properties: strength, hardness, ductility, wear, toughness. Thermal and electrical properties. Chemical properties: corrosion, erosion. Materials failure and analysis.

UNIT 3 Introduction to casting and forming **10 Hrs.**

Introduction to Manufacturing Processes: Classification, Basic Principles and Description, Solidification Processes: Fundamentals of Metal Casting, Glass-working, Shaping Processes for Plastics, Rubber Processing Technologies Metal Forming and Sheet Metal Working: Fundamentals, Bulk deformation processes, Sheet Metal Working

UNIT 4 Introduction to machining **10 Hrs.**

Material Removal Processes: Theory of Metal Cutting, Machining Operations and Machine Tools, CNC Machine Tools. Joining and Assembly Processes: Welding, Brazing, Soldering, Adhesive Bonding, Mechanical Assembly. Modern Approaches in Manufacturing**:** Computer Integrated Manufacturing, Robots in Manufacturing, IoT based solutions for Manufacturing, Industry 4.0 and Manufacturing processes.

42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand significance on various materials and applications.
CO2 – Compare various materials and their properties.
CO3 – List advanced materials and their applications.
CO4 – Summarize the various solidification and forming techniques available for manufacturing.
CO5 – Explain various material removal and joining techniques available for manufacturing.
CO6 – Outline the modern approaches in manufacturing for implementation of Industry 4.0.

TEXT/REFERENCE BOOKS

1. Mikell P. Groover, Fundamentals of Modern Manufacturing-Materials, Processes and Systems, Wiley
2. W. D. Callister, Material Science and Engineering, Wiley
3. Rajender Singh, Introduction to Basic Manufacturing Processes and Workshop Technology, New Age International Publishers

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A: 8 questions 5 marks each 40 Marks
Part B: 6 questions 10 marks each 60 Marks

20ME215T					Rapid Prototyping					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To gain knowledge of Additive Manufacturing
- To gain an insight of working of different AM technologies
- To gain the knowledge of pre and post processing techniques along with applications

UNIT 1 Introduction **11 Hrs.**

Introduction to AM, AM evolution, Distinction between AM & CNC machining, Advantages of AM

AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing. Classification of AM processes: Liquid polymer system, discrete particle system, molten material systems, solid sheet system.

UNIT 2 Design for AM **12 Hrs.**

DFMA concepts and objectives, AM unique capabilities, design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining, Interlocking, Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers.

UNIT 3 Processing Selection and Applications **11 Hrs.**

Guidelines for process selection: Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control

AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries

UNIT 4 Post Processing and Future Directions **11 Hrs.**

Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques. Future Directions of AM: Introduction, new types of products and employment.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Comprehend** various types of 3D printing techniques importance of AM in manufacturing
CO2 - **Examine** the importance of process analysis as applied to AM techniques
CO3 - **Understand** the design tools used in part manufacturing using AM techniques
CO4 - **Select** suitable materials for AM
CO5 - **Comprehend** the different methods for post-processing of AM parts
CO6 - **Understand** the applications of AM and its future direction

TEXT/REFERENCE BOOKS

1. Chua Chee Kai et al "Rapid Prototyping: Principles & Applications", World Scientific, 2003.
2. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory & Practice", Springer, 2006.
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 5 Questions (8 Marks each) 40 Marks

Part B/Question: 5 Questions (12 Marks each) 60 Marks

20IF201T					Industry 4.0					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0	2	2	25	50	25	--	--	100

COURSE OBJECTIVES

- To interpret the core elements and basic technologies of Industry 4.0
- To understand how the core elements and technologies of Industry 4.0 are interconnected
- To develop a holistic approach to improve processes and products with Industry 4.0

UNIT I: INDUSTRY 4.0 – CONCEPTS & TERMINOLOGIES **08 Hrs.**

Industry 4.0, Smart business model, Technology road-map, Sensing & actuation, Communication, Internet of things (IoT), Cyber Physical Systems and Next Generation Sensors, Visualization, Cloud Computing.

UNIT II: SMART WORLD & SUSTAINABLE ENVIRONMENT **08 Hrs.**

Sensors and their integration, Renewable Energy System, Hybrid Energy System, Smart Grid, Smart Metering, Communication Protocols, 5G Technology, Smart Agriculture, Smart Infrastructure, Physiological Sensors, Human Machine Interface.

UNIT III: SMART MANUFACTURING **08 Hrs.**

Automation Systems, Additive Manufacturing, Micro-Electro-Mechanical Systems (MEMS), Smart Factories and Interconnection, Advanced Robotics – Autonomous and Swarm, Self-Propelled Vehicles, Drones–Unmanned Aerial Vehicle (UAV), 3d Printing, Spacecrafts.

UNIT IV: TRANSFORMING TECHNOLOGIES IN BIOENGINEERING **08 Hrs.**

Establishment of Smart Biotechnology Factory, Artificial Intelligence in Bioprocess Technology, 3D Bio Printing for Tissue Engineering, Simulation Tools, RSM and Box Model, Cyber Physical System based Telemedicine, Real Time Biosensors, Bio nanotechnology, biofuel.

Total Hours 32 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the core elements and basic technologies for Industry 4.0
CO2 – Apply the different computational techniques and algorithms for realizing Industry 4.0
CO3 – Transform the traditional business approach by integrating the data and intelligence
CO4 – Develop the traditional industries with intelligent and automated machines
CO5 – Utilize data and intelligence for the development of Smart World
CO6 – Understand the concept, significance and means to achieve sustainable development

TEXT/REFERENCE BOOKS

1. Ustundag Alp, and Emre Cevikcan, Industry 4.0: Managing the Digital Transformation, Springer,First Edition, 2018
2. Kaushik Kumar, Divya Zindani, and J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0., CRC Press, Taylor & Francis First Edition, 2019.
3. Antonella Petrillo, Raffaele Cioffi, and Fabio De Felice, Digital Transformation in Smart Manufacturing., IntechOpen Publisher, First Edition, 2018.
4. J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama and N. Jenkins, Smart Grid: Technology and Applications, John Wiley and Sons Ltd., First Edition, 2012
5. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, First Edition, 2016
6. Ibrahim Garbie, Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0, Springer, First Edition, 2016

20IF201P					Industry 4.0 Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

1. To interpret the core elements and basic technologies of Industry 4.0
2. To understand how the core elements and technologies of Industry 4.0 are interconnected
3. To develop a holistic approach to improve processes and products with Industry 4.0

List of Experiments

1. Basic computations using Python programming.
2. Use simulations to understand the performance/behavior of a system by (i) creating a computational environment that mimics the real world, (ii) generating (synthetic) or loading data from sources, and (iii) testing the hypothesis
3. Introduction to MATLAB programming and SIMULINK
4. 3D printing of Airfoil through rapid prototyping 3D printer
5. Dynamic simulation of drone (unmanned air vehicle) through MATLAB/SIMULINK
6. ANSYS simulation of bending of a beam in an earthquake resist-building
7. Introduction to Arduino Embedded platform.
8. Design of line follower autonomous vehicle.
9. Design of smart meter for recording the electricity consumption
10. Design of smart lighting with the help of proximity sensors.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Understand the concept of Industry 4.0 and its significance
CO2 – Understand the resource requirements for the implementation of Industry 4.0
CO3 – Learn the Simulation Packages for Industry 4.0
CO4 – Explore the concept of Smart Infrastructure through simulation studies
CO5 – Inspect embedded platform applications for Industry 4.0
CO6 – Synthesise the solution for the given Industry 4.0 related problem

TEXT/REFERENCE BOOKS

1. Ustundag Alp, and Emre Cevikcan, Industry 4.0: Managing the Digital Transformation, Springer,First Edition, 2018
2. Kaushik Kumar, Divya Zindani, and J. Paulo Davim, Digital Manufacturing and Assembly Systems in Industry 4.0., CRC Press, Taylor & Francis First Edition, 2019.
3. Antonella Petrillo, Raffaele Cioffi, and Fabio De Felice, Digital Transformation in Smart Manufacturing., IntechOpen Publisher, First Edition, 2018.
4. J. Ekanayake, K. Liyanage, J. Wu, A. Yokoyama and N. Jenkins, Smart Grid: Technology and Applications, John Wiley and Sons Ltd., First Edition, 2012
5. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things, Apress, First Edition, 2016
6. Ibrahim Garbie, Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0, Springer, First Edition, 2016

20ME208P					Mechanical Drawing Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	02	-	-	-	25	25	50

COURSE OBJECTIVE

- To be able to draw computer-aided mechanical drawings of components and assemblies of industrial machines, machinery parts and other mechanical equipment by CAD software

List of exercises:

1	Recapitulate concepts of sketch entities and tools, 3D features	2 Hrs
2	Use of advanced 3D features like lofted base, revolved base, sweep, draft, wrap and mirroring features	2 Hrs
3	To create different types of mechanical springs – compression, torsional and extension strings	2 Hrs
4	To create 3D assembly of mechanical systems and edit parts in the assembly.	2 Hrs
5	Create and edit Bill of Materials (BOM)	2 Hrs
6	Use of motion study tool, animate the assembly and detect interference/clearance	2 Hrs
7	To create threads using ANSI standards. To study thread features – internal and external threads, threaded blind holes, thread pitch.	2 Hrs
8	Tolerance – Limit tolerance, angular tolerance, geometric tolerances.	2 Hrs
9	Fit Tolerances – Clearance fits, hole basis & shaft basis, Interference fits	2 Hrs
10	To study bearings toolbox – Ball Bearings and manufactured bearings	2 Hrs
11	To create gears and gear assembly.	2 Hrs
12	To study power transmission from shaft to gears and create bearing-gear assembly	2 Hrs
13	Assembly drawings using industry standards	2 Hrs
	Total	**26 Hrs**

COURSE OUTCOMES

On completion of the course, student will be able to

CO-1: Demonstrate competency with multiple drawing and modification commands in SolidWorks.
CO-2: Create three-dimensional solid models.
CO-3: Create three-dimensional assemblies of mechanical systems with permissible tolerances.
CO-4: Apply industry standards in the preparation of technical mechanical drawings.
CO-5: Communicate and present ideas and solutions to design problems using interactive motion study tool
CO-6: Design/draft the next innovative thing

TEXT/REFERENCE BOOKS

1. Zeid, Ibrahim. Mastering Solidworks. Prentice Hall Press, 2010.
2. Weber, Matt, and Gaurav Verma. SolidWorks 2015 Black Book. CreateSpace Independent Publishing Platform, 2014.
3. Rao, Posinasetti Nageswara. CAD/CAM: principles and applications. Tata McGraw-Hill Education, 2004

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50	**Exam Duration: 2Hrs**
Part A: Lab work	25 marks
Part B: Viva Voce	25 Marks

Course Structure of B. Tech. in Mechanical Engineering

COURSE STRUCTURE FOR B.TECH. THIRD YEAR (Mechanical Engineering)

SEMESTER V (Subjects)				B.TECH. THIRD YEAR (Mechanical Engineering)											
Sr. No.	Category Code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	CE	MS	ES	CE	ES	
1	PCC	20ME301T	Heat Transfer	3	0	0	3	3	25	25	50	-	-	100
2	PCC	20ME301P	Heat Transfer - Lab.	0	0	2	1	2	-	-	-	25	25	50
3	PCC	20ME302T	Dynamics of Machine	3	0	0	3	3	25	25	50	-	-	100
4	PCC	20ME302P	Dynamics of Machine -Lab.	0	0	2	1	2	-	-	-	25	25	50
5	PCC	20ME303T	Manufacturing Process - I	3	0	0	3	3	25	25	50	-	-	100
6	PCC	20ME303P	Manufacturing Process - I - Lab.	0	0	2	1	2	-	-	-	25	25	50
7	PCE	20ME30XT	Professional Core Elective - II	3	0	0	3	3	25	25	50	-	-	100
8	PCE	20ME30XP	Professional Core Elective - II Lab	0	0	2	1	3	25	25	50	-	-	100
9	OE	20ME3XXT	Open Elective - III	3	0	0	3	3	25	25	50	-	-	100
10	HSC	20HS301P	Communication Skills - III	0	0	2	1	2	-	-	-	50	50	100
			Total	**15**	**0**	**10**	**20**	**25**						

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

Professional Core Elective – II:

Course Code	Course Name		Course Code	Corse Name		Course Code	Course Name
20ME304T	Renewable and Sustainable Energy Technologies		20ME304P	Renewable and Sustainable Energy Technologies Lab		20ME308T	Design for Manufacturing
20ME305T	IC Engines and Gas Turbines		20ME305P	IC Engines and Gas Turbines Lab		20ME308P	Design for Manufacturing Lab
20ME306T	Fluid Machinery		20ME306P	Fluid Machinery Lab			
20ME307P	Computer Aided Design Lab		20ME307T	Computer Aided Design			

Open Elective – III:

Course Code	Course Name		Course Code	Course Name
20ME309T	Dynamics and Control of Unmanned Aerial Vehicle		20ME311T	Additive Manufacturing in Industry 4.0
20ME310T	Work Design and Measurement		20ME312T	Applied Data Analysis and Machine Learning

20ME301T					Heat Transfer					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To Cover the basic principles of heat transfer
- To introduce real world engineering examples to give students a feel for how heat transfer is applied in engineering practice.
- To develop an intuitive understanding of heat transfer by emphasizing the physics and physical arguments.

UNIT 1 Conduction **12 Hrs.**

Introduction: modes, mechanisms and basic concepts of heat transfer; Fourier's law, effect of thermal conductivity, thermal diffusivity; Industrial applications. **Heat Conduction:** Generalized (3D) heat conduction equation in the Cartesian, cylindrical and spherical co-ordinates; One dimensional steady state solutions (with and without heat generation); temperature profile and heat transfer equations; Boundary conditions; wall, cylinder, sphere and composites; electrical analogy; overall heat transfer coefficient; Variable thermal conductivity; critical radius of insulation. Extended surfaces: fin performance parameters. Numerical calculation. **Transient heat conduction**: lumped system analysis; approximate analytical and graphical solutions for plane walls and semi-infinite solids.

UNIT 2 Convection **12 Hrs.**

Heat Convection: Classification, physical mechanism and dimensional analysis applied to forced and free convection; local and average heat transfer coefficients and dimensionless numbers; Thermal and hydrodynamic boundary layers; Differential convection equations and solutions for flat plate; Analogies between momentum and heat transfer; laminar and turbulent heat flow correlations for external flow. **Internal forced convection:** concept of average velocity and temperature; entrance region; General thermal analysis for laminar flow in a tube; heat transfer correlations for laminar and turbulent flow. **Free convection:** Equation of motion and the Grashof number; natural convection over surfaces and inside enclosures; combined natural and forced convection. **Boiling and Condensation:** Boiling regimes and the boiling curve; Film and drop wise condensation; correlations. flow boiling

UNIT 3 Radiation **10 Hrs.**

Thermal Radiation: Industrial applications, Concept of radiation, absorptivity, reflectivity & transmissivity, blackbody, grey surfaces, emissive power & emissivity. Laws of radiation – Planck, Stefan – Boltzman, Wein's displacement, Kirchoff. Intensity of radiation & solid angle, Lambert's cosine law, shape factor. Radiation heat exchange between black bodies, geometric configuration factor, heat exchange between diffuse-grey bodies-radiation shield, heat exchange between enclosed grey surfaces, electrical analogy to simple problems and non-luminous gas radiation.

UNIT 4 Heat exchanger **8 Hrs.**

Heat Exchangers: Industrial applications, classification, heat exchange performance analysis, LMTD for parallel & counter flow heat exchanger, overall heat transfer coefficient, fouling, correction factor for multi-pass arrangement, effectiveness and number of transfer unit for parallel and counter flow heat exchanger, cross flow, **TEMA standards**. **Introduction to Mass Transfer:** Fick's law; Analogy between heat and mass transfer; Mass diffusion: mass and molar basis; Diffusion through a stationary and moving medium; mass convection and analogies.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Comprehend** modes of heat transfer and **apply** principles of heat transfer to solve engineering problems.
CO2 - **Analyze and Solve** problems involving steady and unsteady heat conduction
CO3 - **Evaluate** convection heat transfer problems for a variety of flow conditions using appropriate convection correlations
CO4 - **Analyze** heat exchanger performance using LMTD and NTU methods
CO5 - **Evaluate** radiative heat exchange between two or more surfaces of different geometries
CO6 - **Understand** the basic principles of mass transfer

TEXT/REFERENCE BOOKS

1. Yunus A. Cengel and Afshin J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill Education. Fifth edition, 2017.
2. F. P. Incropera and D. P. DeWitt, Introduction to Heat Transfer, Wiley, , New York, 5th edition, 2006.
3. J. P. Holman, Heat Transfer, Tata McGraw Hill Education, 10th Edition, 2017.
4. F. White, Heat and Mass Transfer, Pearson Education (US), 1988.
5. S. P. Sukhatme, A Textbook of Heat Transfer, Universities Press, 4th Edition, 2005.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Unit 1/ Question: two questions with subsections	20 Marks
Unit 2/Question: two questions with subsections	20 Marks
Unit 3/ Question: two questions with subsections	30 Marks
Unit 4/Question: two questions with subsections	30 Marks

20ME301P					Heat Transfer Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- **To analyse, differentiate** and **evaluate** different modes of heat transfer through various mediums.
- **To evaluate** steady and transient state properties of heat transfer mediums.
- **To calculate and compare** the performance of heat exchangers.

List of Experiments:

1. To identify the thermal Conductivity of Metal Rod
2. To identify the thermal Conductivity of Insulating Powder
3. To identify the convective heat transfer of air in natural convection mode
4. To identify the convective heat transfer of air in force convection mode
5. To identify the effect of orientation in natural convection heat transfer
6. To find out the performance parameter of concentric tube heat exchanger
7. To verify the Stefan Boltzmann constant
8. To identify the emissivity of a test material

Max. 26 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Understand** the engineering examples of different modes of heat transfer
CO2 - **Evaluate** and verify heat transfer modelling through experimentation
CO3 - **Understand** and **analyse** emissivity of a given materials.
CO4 - **Understand** and **analyse** thermal conductivity of a given insulating powder
CO5 - **Examine** the performance of heat exchangers.
CO6 - **Compile** and interpret the experimental data at steady state condition

TEXT/REFERENCE BOOKS

1. Yunus A. Cengel and Afshin J. Ghajar, Heat and Mass Transfer: Fundamentals and Applications, McGraw Hill Education. Fifth edition, 2017.
2. F. P. Incropera and D. P. DeWitt, Introduction to Heat Transfer, Wiley, , New York, 5th edition, 2006.
3. J. P. Holman, Heat Transfer, Tata McGraw Hill Education, 10th Edition, 2017.
4. F. White, Heat and Mass Transfer, Pearson Education (US), 1988.
5. S. P. Sukhatme, A Textbook of Heat Transfer, Universities Press, 4th Edition, 2005.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Quiz/Experiment	10 Marks
Viva	15 Marks

20ME302T					Dynamics of Machines					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the effect of forces (static and dynamic) on the behaviour of a body/system.
- To comprehend the function, motions and force distribution in elements like Gears, Gyroscopes, Brakes etc.
- To develop an ability to analyse the motions in various types of gear trains.
- To determine the unbalance in a system and subsequently balance it.
- To understand the tribological behaviour of materials.

UNIT 1 **12 Hrs.**

Static Force Analysis: Static equilibrium, equilibrium for two force and three force members, torque, Force convention, Free body diagrams, Superposition, Virtual work.
Dynamic Force Analysis: D'Alembert's Principle, Dynamic analysis of four link, slider crank, Velocity and acceleration of automobile components, Turning moment, Dynamically equivalent system, Turning Moment Diagrams, Fluctuation of energy, Flywheels.

UNIT 2 **12 Hrs.**

Gears: Laws of gearing, gears terminology, tooth form, standard interchangeable tooth profile, minimum number of teeth on pinion in contact with a gear, interference and under cutting, bevel, helical and spiral gears.
Gear Trains: Simple, compound, reverted and epicyclic gear trains, analytical and tabular methods, torques in epicyclic train, differential gear box.
Gyroscope: Angular velocity, angular acceleration, gyroscopic torque, gyroscopic effect on naval ships and aeroplanes, stability of an automobile, two-wheel vehicle.

UNIT 3 **11 Hrs.**

Brakes and Dynamometers: Introduction, General description and study of operating principle.
Balancing: Balancing of rotating masses in single and multiple planes.
Balancing of Reciprocating Masses: Primary and secondary balancing of reciprocating masses. Unbalanced forces and couples examination of "V", multi cylinder in line and radial engines for primary and secondary balancing.

UNIT 4 **10 Hrs.**

Tribology and Lubrication: Introduction to Tribology, Solid Surface Characterization, Friction, Solid-solid contact, liquid mediated contact, Friction of materials, Wear, Types of Wear Mechanisms, Types of Particles present in wear debris Wear of Materials, Fluid Film Lubrication, Hydrostatic Lubrication, Hydrodynamic Lubrication, Elasto-hydrodynamic Lubrication, Boundary Lubrication, Liquid Lubricants.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – Evaluate the effect of static and dynamic forces on a mechanism.
CO2 – Analyse the working of different types of gears and gear trains.
CO3 – Evaluate the gyroscopic couples in devices involving rotating masses.
CO4 – Analyse the unbalanced forces in systems with rotating and reciprocating masses.
CO5 – Demonstrate the working of brakes and dynamometers
CO6 – Explain the tribological behaviour of materials under dry and lubricated conditions.

TEXT/REFERENCE BOOKS

1. S. S. Ratan Theory of Machines, Tata Mc Graw-Hill publications, New Delhi
2. Ghosh Amitabha, Theory of Mechanisms and Machines, East West Press
3. Rao J.S. and Dukkipati R.V, Mechanisms and Machines Theory, Wiley Eastern Ltd.
4. B. Bhushan, Introduction to Tribology, Wiley
5. Shigley J.E and Uicker J.J, Theory of Mechanisms and Machines, Oxford University Press
6. I. M. Hutchings, Tribology, Friction and Wear of Engineering Materials.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**
Part A: 6 questions 5 marks each 30 Marks
Part B: 7 questions 10 marks each 70 Marks

20ME302P					Dynamics of Machines Lab.		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester	
-	-	2	1	2	25	25	50

COURSE OBJECTIVES

- To analyze the behavior of bodies undergoing vibrations, both theoretically as well as practically.
- To statically and dynamically balance an unbalanced rotating system.
- To calculate Gyroscopic Torques in a Gyroscope apparatus.
- To compare the behavior of various configurations of Governors.
- To analyze and interpret data across all practical.

List of Experiments

1. To study Undamped free vibrations (longitudinal) of a spring mass system
2. To study Undamped free vibrations (torsional) of a single rotor system
3. To determine the natural frequency of a two rotor system
4. To determine the Gyroscopic couple and its effect on a rotating disc
5. To demonstrate the effect of static and dynamic unbalance in a system.
6. To completely balance a system of rotating masses.
7. To find the damping coefficient of a system undergoing torsional oscillations
8. To plot the characteristics of Forced Damped Vibrations for the given system
9. To demonstrate whirling of shafts
10. To determine the characteristics of governors
11. To determine the jump speed of a Cam-follower system
12. To determine the radius of gyration of a body using Bi-filar and Tri-filar Suspension.

Max. 24 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Analyse** the behaviour of bodies undergoing vibrations, both theoretically as well as practically
CO2 - **Apply** the principles of force and couple balance to statically and dynamically balance an unbalanced rotating system
CO3 –**Compute** the damping coefficient of system subjected to transverse and torsional vibrations.
CO4 - **Compare and assess** the dynamic behaviour of various mechanisms
CO5 - **Understand** the principles of gyroscope and governors
CO6 – **Illustrate and apply** a method to compute moment of inertia of rigid bodies

RESOURCES/TEXT/REFERENCE BOOKS

1. Dynamics of Machines Lab Manual.
2. Rattan, S.S., 2014. Theory of machines. Tata McGraw-Hill Education.

END SEMESTER LAB EXAMINATION

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz/Experiment	10 Marks
Viva-Voce	15 Marks

20ME303T					Manufacturing Process-I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide the basics & advances in manufacturing processes, their classification, advantages & disadvantages.
- To provide the fundamentals and working principles of casting, welding, and metal working processes.
- To provide the basics of manufacturing of plastics and powder materials.

UNIT 1 Casting **12 Hrs.**

Introduction to manufacturing-classification-challenges-selection. Introduction to casting, foundries, types of castings-patterns-allowances-moulding sand and ingredients-gating system-cores-chaplets-crucibles. Making of-Patterns-Cores-Casting design. Solidification of casting. Casting of metals-plastics. Casting Types-Sand Casting-Permanent-Investment-Die-Centrifugal-Continuous-CO2 Casting-Evaporative pattern. Casting defects, prediction and remedies,

UNIT 2 Metal Working Processes **11 Hrs.**

Classification and concepts of metal working processes. **Forging**-Principles-Classifications-Tools-Dies-Defects. **Rolling**- Fundamentals-Theory-Tools-Types-Defects.**Extrusion**-Classifications-Tools-Dies-Operations-Defects. **Drawing**-Wires-Bars-Tubes-Forces. **Sheet metal forming-**Bending- Deep drawing-Roll forming- Stamping-Spinning-Peen forming.

UNIT 3 Welding **12 Hrs.**

Introduction-Welding-Soldering-Brazing. Classification of welding-fluxes. Gas welding-ARC- MIG-TIG-Resistance-Spot-Thermite-Plasma-Induction-Explosive-Forge-Friction-Frictional Stir-Laser-E-beam-Plasma. Weld joints-Weldability-Metallurgical Characteristics-Defects-Causes-Remedies. Destructive and NDT of welds.

UNIT 4 Other Manufacturing Processes **10 Hrs.**

High energy rate forming processes-under water explosions-spark discharge, Pneumatic mechanical means, internal combustion of gases, and rapid force magnetic fields. Powder Forming-Techniques-Classifications-Applications. Processing of Plastics-Moulding Types-Properties-Application-Equipment-Injection-Blow-Extrusion-Vacuum Forming-Compression moulding-Rotational Moulding-Thermo Forming.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define the fundamentals of manufacturing processes and their classifications.

CO2 - Understand the working principles of various casting processes.

CO3 – Demonstrate the equipment and tools used in different manufacturing technologies such as forging, rolling, extrusion, drawing and sheet metal forming.

CO4 - Classify various types welding processes and their significance.

CO5 - Explain the different characteristics of weld joints.

CO6 – Choose the appropriate manufacturing process of powder forming and processing of plastics.

TEXT/REFERENCE BOOKS

1. Serope Kalpakjian, Manufacturing engineering and Technology, Wesley Publishing Co.
2. Lindberg R.A, Processes and Materials of Manufacture, Prentice Hall of India (P) Ltd.
3. P.N.Rao, Manufacturing & Technology: Foundry Forming and Welding, Tata McGraw Hill Publications.
4. Chee Kai Chua, Kah Fai Leong, Chu Sing Lim, Rapid prototyping: Principles and applications, World scientific publications.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 4 Questions from all units together - each carrying 5 marks	20 Marks
Part B/Question: 2 Questions from each unit each carrying 10 marks	80 Marks

20ME303P					Manufacturing Process-I Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- To analyse and understand various welding techniques.
- To study the use of weld gauges
- Familiarize various ASTM standards relevant to weld joints
- To understand moulding process
- To understand and analyse types of defects in welding, casting and metal forming processes

List of Experiments:

1. To study the safety aspects of welding, casting and metal forming operations
2. Shielded metal arc welding & effects of variables on bead geometry
1. Gas metal arc welding & effects of variables on bead geometry, Gas tungsten arc welding & effects of variables on bead geometry, Gas welding, Gas cutting & effects of variables on cutting quality
1. Plasma cutting & effects of variables on cutting quality
2. Resistance welding spot, projection, butt welding
3. To understand the use of various welding gauge
4. Soldering and Brazing
5. Injection moulding of plastics
6. Development of macro and micro structure of welded joints
7. Demonstration of sand casting operations & manufacturing of various cast products
8. Friction welding using lathe machine, Friction Stir Welding using vertical milling machine
9. Study various ASTM standards for mechanical testing of welded joints & welding terminology
10. Over view of various welding, casting and metal forming defect & it relevance

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – **Understand** various metal joining techniques
CO2 – **Analyse** the effect of process parameters on weld quality
CO3– **Examine** Weld parameters required for a given weld process
CO4 – **Produce** sand cast mould and cast a component
CO5 – **Evaluate** weld quality of the friction welded joints
CO6 – **Understand** various types of defects in welding, casting and metal forming processes

TEXT/REFERENCE BOOKS

1. P. N. Rao, Manufacturing & Technology: Foundry Forming and Welding, Tata McGraw Hill Publications.
2. Serope Kalpakjian, Manufacturing engineering and Technology, Wesley Publishing Co.
3. Lindberg R.A, Processes and Materials of Manufacture, Prentice Hall of India (P) Ltd.
4. Roy A Lindberg, Process and Materials of Manufacturing, Pearson Edu.
5. Serope Kalpakjian & Steuen. R. Sechmid, Manufacturing Technology, Pearson Education Asia.
6. Taylor H.F Flemings M.C & Wulff J., Foundry Engineering, Wiley Eastern Limited.

END SEMESTER LAB EXAMINATION

Max. Marks: 25 **Exam Duration: 2 Hrs**

Quiz/Experiment	10 Marks
Viva-Voce	15 Marks

20ME304T					Renewable and Sustainable Energy Technologies					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of basics of different sustainable type energy sources
- To identify the sustainable energy technologies applicable in mechanical industries

UNIT 1 Solar Energy **(12)**

Principles of solar radiation - physics of the sun, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, **Solar energy collection** - Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors, **Solar energy storage and applications** - Different methods, Sensible, latent heat and stratified storage, solar ponds. Solar Applications- solar heating/cooling technique, solar distillation and drying, **Photovoltaic energy conversion** - Photovoltaic, p-n junction, solar cells, PV systems, Stand-alone, Grid connected solar power

UNIT 2 Biomass Energy **(10)**

Biogas - Principles of Bio-Conversion, Anaerobic/aerobic digestion, types of Bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, **Biomass gasification** - Biomass conversion technologies, Constructional details of gasifier, **Biofuels** - Introduction and perspective of biofuels, biofuel production and applications, energy plantation, environmental impact of biofuel, Biofuel operated I.C. Engine operation and economic aspects, Biomass pallets and its applications

UNIT 3 Wind Energy **(10)**

Principle of wind energy conversion, Basic components of wind energy conversion systems - Lift and Drag– Effect of density, frequency variances, angle of attack, and wind speed - design considerations of horizontal and vertical axis wind machines - analysis of aerodynamic forces acting on wind turbine blades and estimation of power output - wind data and site selection considerations, speed control devices for wind turbine

UNIT 4 Other Renewable Energy **(10)**

Energy from Ocean – Basic cycles of Ocean Thermal Energy Conversion, basic principle of tidal power, wave energy conversion devices, **Fuel Cells** - Introduction, Design principle and operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells, **Geothermal Energy** - nature of geothermal energy, geothermal sources and resources like hydrothermal, geo-pressured hot dry rock, magma. advantages, disadvantages and application of geothermal energy, prospects of geothermal energy in India, **Hydrogen Energy** - Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand the principle of solar radiation and its availability at various locations.
CO2: Evaluate the ways to use solar energy for various applications like heating, cooling, water distillation and electricity and evaluate their performance.
CO3: Interpret and classify the ways to harness the energy from Biomass.
CO4: Understand and analyze the Wind and wave energy conversion.
CO5: Summarize the ways to harness energy from other renewable energy sources like geothermal, ocean, Fuel cell, hydrogen etc.
CO6: Recognize the need and ability to engage in lifelong learning for further developments in this field.

TEXT/REFERENCE BOOKS

1. Sukhatme, S.P. and Nayak, J.K., 2017. Solar energy. McGraw-Hill Education
2. Duffie, J.A., Beckman, W.A. and Worek, W.M., 2013. Solar engineering of thermal processes (Vol. 3). New York: Wiley
3. Zobaa, A.F. and Bansal, R.C., 2011. Handbook of renewable energy technology. World Scientific.
4. Kothari, D.P., Singal, K.C. and Ranjan, R., 2011. Renewable energy sources and emerging technologies. PHI Learning Pvt. Ltd.
5. Desai, A.V., 1990. Nonconventional energy (Vol. 8). New Age International.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks 20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks 80 Marks

20ME304P					Renewable and Sustainable Energy Technologies Lab		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester LE/Viva	
0	0	2	1	2	25	25	50

Course objectives:

- To **demonstrate** working of solar energy application.
- To **understand** the Biofuel production technics
- To **measure and interpret** solar radiation and wind velocity data.
- To **evaluate** the performance of sustainable energy technologies

List of Experiments:

1. Measurement of weather conditions using automatic weather station
2. Performance characteristic of solar flat plate collector
3. Performance characteristic of parabolic trough collector
4. Demonstration of evacuated tube solar collector technology
5. Performance characteristic of solar cooker
6. Performance evaluation of solar still
7. Performance evaluation of Solar PV system
8. Performance study of Phase Change Material based thermal energy storage system
9. Determination of moisture content in food sample
10. Performance study of solar drying system
11. Performance characteristic of wind turbine
12. Determine the calorific value of given sample of fuel
13. Analyze the biofuel properties

Max Hrs: 26

Course Outcomes (COs):

On completion of the course, students will be able to

CO1: Understand the weather data and their measurements.
CO2: Evaluate and discuss experimental uncertainty.
CO2: Identify the sustainable energy technologies wherever feasible in mechanical industries.
CO3: Evaluate the performance of sustainable energy systems.
CO4: Construct chart and graphs.
CO5: Create publication-quality lab reports.
CO6: Enhance the presentation and team work skills.

TEXT/REFERENCE BOOKS

1. Sukhatme, S.P. and Nayak, J.K., 2017. Solar energy. McGraw-Hill Education
2. Duffie, J.A., Beckman, W.A. and Worek, W.M., 2013. Solar engineering of thermal processes (Vol. 3). New York: Wiley
3. Zobaa, A.F. and Bansal, R.C., 2011. Handbook of renewable energy technology. World Scientific.
4. Kothari, D.P., Singal, K.C. and Ranjan, R., 2011. Renewable energy sources and emerging technologies. PHI Learning Pvt. Ltd.
5. Desai, A.V., 1990. Nonconventional energy (Vol. 8). New Age International.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs**

Part A: Lab work 25 Marks
Part B: Viva voce 25 Marks

20ME305T					IC Engines and Gas Turbines					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To classify and analyse various SI and CI engine components and gas turbines and cycle with combustion phenomenon
- To evaluate the performance parameters of SI and CI engines for various conditions
- To Classify, Analyse and evaluate the performance and performance parameters of Steam and Gas turbines.
- To Understand the jet propulsion system.

Unit: I - Introduction to IC Engines **10hr**

Introduction to IC engines: Engine Classification, four stroke and 2 stroke engines, SI and CI engines. Air standard cycles and fuel air cycles. Engine performance parameters, valve timing diagram.

Unit: II – Fuel and Lubrication System in IC Engines **10hr**

Fuel supply systems in SI and CI engines, Carburettors, Port fuel injection, Direct injection and Common rail injection Ignition system, lubrication system and cooling systems. Testing of IC engines

Unit: III - Introduction to Gas turbines **10hr**

Introduction to Gas turbines: Gas turbines Classification, and its application, Compressor and Turbines. Simple open and close cycle gas turbine, efficiency and specific output of simple cycle, effects of – regeneration, re-heating and inter-cooling on efficiency and work output, effect of operating variables on thermal efficiency, air rate, work ratio; water injection, performance and application of gas turbine, Performance analysis of Bryton Cycle, Combined and cogeneration cycle. Jet Propulsion: Introduction to jet propulsion, advantages and disadvantages of jet propulsion – turbojet engine with and without after burner, turboprop, ram jet, pulse jet, rocket engines – operation, solid and liquid propellants.

Unit: IV – Combustion in IC Engines and Gas Turbines **10hr**

Combustion in IC engines: Combustion in SI engines, abnormal combustion and knock in SI engines, combustion chambers for SI engines, Combustion in CI engines, knocking in CI engines, combustion chambers for CI engines, abnormal combustion in SI and CI engines. Engine emissions and control: products of combustion in IC engines, control of pollutants from IC engines, emission standards for IC engines. Combustion in Gas turbines: Introduction to Combustion process in gas turbine, Combustion system. Types of Combustion system, requirement of Combustion chamber

Max 40 hrs

Course Outcomes (CO's):

On completion of the course, students will be able to

CO1: Understand and analyse various SI and CI engine cycle with combustion phenomenon
CO2: Understand and analyse the systems for CI and Si engines
CO3: Evaluate the performance parameters of SI and CI engines
CO4: Analyse and evaluate the performance and performance parameters of Gas turbines
CO5: Classify the steam and gas turbine and understand the construction and working of it
CO6: Understand and analyse jet propulsion system

Text and reference Books:

1. V. Ganesan, Internal Combustion Engines, 3rd edition, The Tata McGraw-Hill publications
2. H. N. Gupta, Fundamentals of Internal Combustion Engines, Prentice Hall India pvt. Ltd.
3. Gas Turbines, Cohen & Rogers, Pearson Prentice Hall
4. Fundamentals of Gas Dynamics by Robert D. Zucker and Oscar Biblarz, John Wiley & Sons

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A: 4 Question form each unit – 10 marks each 40 Marks
Part B: 6 Numerical Questions – 10 marks each 60 Marks

20ME305P					IC engine and Gas turbine LAB		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					LW	LE/Viva	
-	-	2	0	2	25	25	100

COURSE OBJECTIVES

- To study and identify different aggregates of IC engines and understand the working principle and mechanism of different system in IC engines.
- To analyse exhaust gas pollution of an IC engine under various loading conditions.
- To measure the performance parameter and evaluate the system performance of various IC engines under variable loading condition.

List of Experiments

Experiment 1: To study the various components and its working by using cut section model of SI and CI engine.

Experiment 2: To study port timing diagram on 2 stroke engines.

Experiment 3: Performance test on 4Stroke-4 Cylinder SI engine under constant load and variable speed conditions.

Experiment 4: Performance test on 4Stroke-4 Cylinder SI engine under variable load and constant speed conditions.

Experiment 5: Performance test on single cylinder 4Stroke CI engine under variable load conditions.

Experiment 6: Performance of Morse test on Muti-cylinder engine.

Experiment 7: To analyse heat loses in CI engine with the help of heat balance sheet.

Experiment 8: To study indicator diagram on 4 stroke engines.

Experiment 9: To analyse composition of exhaust gases on a 4-stroke engine under various loading condition by using gas analyser.

Experiment 10: To study and demonstrate the working of turbo-charged BMW engine.

Experiment 11: To study and demonstrate the working of ignition, lubrication and cooling in a Ford engine.

Max Hrs: 26

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recognize** and understand various parts and systems of IC engines
CO2: **Evaluate** the performance test on IC engines.
CO3: **Demonstrate** experiments and analysis on Exhaust gases for various IC engines under variable loading condition.
CO4: **Demonstrate** the experimental study on IC engines to obtain the indicator diagram and prepare heat-balance sheet and different efficiencies.
CO5: **Evaluate** the performance of petrol and diesel engines and analyse effect of variation of various performance parameters with load and speed.
CO6: **Develop** ability to run engines in controlled laboratory environments and organize and report experimental results.

TEXT/REFERENCE BOOKS

1. M.L. Mathur and R.P. Sharma, A COURSE IN INTERNAL COMBUSTION ENGINES, Dhanpar Rai Publications.
2. Heywood, J. B. Internal Combustion Engine Fundamentals. NMcGraw-Hill,
3. Colin R. Ferguson and Allan T. Kirkpatrick, Internal Combustion Engines Applied Thermo sciences, 2nd edition, John Wiley & Sons.
4. V. Ganesan, Internal combustion engines, McGraw-Hill

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 2 Hrs**

Part A: Quiz/Experiment - Manual 25 Marks

Part B: Viva 25 Marks

20ME306T					Fluid Machinery					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand basics of the energy conversion in fluid machines
- To understand working and performance of various machines.
- How to compare and chose fluid machines for various operations.

UNIT 1 FUNDAMENTALS OF FLUID MACHINES **09 Hrs.**

Introduction: Definition and classification of turbo machines; Principles of operation; Energy transfer in turbo machines. Momentum Principles: Action of jets on stationary and moving flat plates and curved vanes; Angular momentum principle; Torque and efficiency of roto-dynamic machines.

UNIT 2 HYDRAULIC TURBINES **13 Hrs.**

Classification; Impulse; Reaction; Radial, Axial, mixed and tangential flow turbines; Pelton, Francis turbines; Runner profiles; Velocity triangles; Head and efficiency; Draft tube theory; Similarity laws; Concept of specific speed and unit quantities; Selection of Turbines; Operational characteristics.

UNIT 3 HYDRAULIC PUMPS **13 Hrs.**

Working principles and classification of pumps; Centrifugal Pumps:; working principle of roto-dynamics pumps; Manometric head, Losses and efficiencies; velocity vector diagrams and work done; Priming; Performance and characteristic curves; NPSH and Cavitation; Similarity relations and specific speed; design considerations; multi-stage pumps. Reciprocating Pumps: Construction and operational details; work and power input; volumetric efficiency and slip; separation; air vessels and their utility; maximum speed of the rotating crank; characteristic curves, regenerative pumps and its application

UNIT 4 AIR COMPRESSOR, FAN AND BLOWER **10 Hrs.**

Air Compressor: Working principles and classification; Reciprocating air compressor : compression process, work of compression, single and multi stage compression, volumetric efficiency, air motors. Rotary compressor: centrifugal and axial flow compressor, positive displacement compressor, velocity diagram, Analysis, Design and construction features. Compressor characteristics, surging and choking. Fans & Blowers: Working principles; types; velocity diagrams; stage parameters, design parameters, losses, screw compressor and its application

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1- Identify various types of fluid machines and their principal applications.
CO2- Understand working principles, operating characteristics and factors affecting performance of fluid machines.
CO3- Estimate main operating parameters such as forces, torque, flow rate and efficiencies of fluid machines.
CO4- Apply basic conservation equations to predict the performance of different fluid machines.
CO5 - Evaluate a similarity analysis between a laboratory tested model and a full scale fluid machine.
CO6- Select appropriate fluid machine for practical use.

TEXT/REFERENCE BOOKS

1. Shepherd, D. G., Principles of Turbo machinery, Collier Macmillan, 1971
2. S. L. Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery, Pergamon Press Ltd., 2014
3. R. K. Turton, Principles of Turbomachinery, Springer, 1994
4. Wright, T., Fluid Machinery: Performance, Analysis and Design, CRC Press, 1999
5. S.M. Yahya, Turbines, Compressor and Fan, McGraw-Hill, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

10 Questions each of 10 marks from above units with appropriate marks distribution among designed Course Outcomes (COs) 100 Marks

20ME306P					Fluid Machinery Lab.					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	25	25	50

COURSE OBJECTIVES

- To understand the working principle of different fluid machines.
- To develop an ability in student to design and conduct experiments on Fluid Machines.
- To determine the performance characteristics of hydraulic turbines.
- To determine the performance characteristics of different pumps.

LIST OF EXPERIMENTS

1. Determination of coefficient of impact for water jet striking different shaped vanes.
2. To study performance characteristics of the Pelton Wheel Turbine with different spear valve settings.
3. To determine performance Characteristics of the Propeller Turbine with different Guide Vane settings
4. To study the Performance Characteristics of the Francis Turbine with different Guide Vane settings
5. To study and verify the performance characteristics of centrifugal pump.
6. To determine the performance characteristics of reciprocating pump.
7. Experiment on performance characteristics of axial flow fan.

COURSE OUTCOMES (CO's):

On completion of the course, student will be able to

CO1: Apply Balance of momentum principle to calculate force on flat and curved vane.
CO2: Identify and perform critical experimental procedures to isolate the experimental errors.
CO3: Evaluate performance characteristics of different Fluid machines for a wide range of operating conditions.
CO4: Analyze different flow parameters in hydraulic circuits. Judge the sensor reading for errors; quantify/calibrate different types of errors in experimental setup.
CO5: Evaluate the efficiency/efficiencies of fluid machines by comparing system output and input parameters of the studied hydraulic-system.
CO6: Classify the experimental reading to analyze, interpret and report the performance parameters of Fluid-Machines/Fluid-systems.

TEXT/REFERENCE BOOKS

1. Laboratory Manual
2. S K Som, G Biswas, Suman Chakraborty, Introduction to Fluid Mechanics & Fluid Machines, McGraw Hill Education; 3 edition.
3. G. Ingram, Basic Concepts in Turbomachinery, Grant Ingram & Ventus Publishing
4. Sayers, A.T., Hydraulic and Compressible Flow Turbo machines, McGraw Hill
5. S.L. Dixon, Fluid Mechanics, Thermodynamics of Turbomachinery, Pergamon Press Ltd.

END SEMESTER LAB EXAMINATION

Max. Marks	**Exam Duration: 2 hrs**
Quiz/Experiment	10 Marks
Viva	15 Marks

20ME307T					Computer Aided Design					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

Prerequisites: Engineering Graphics**,** Design and Kinematics of Machines**,** Machine Design-I

COURSE OBJECTIVES

- To impart knowledge on CAD entities
- To provide the knowledge of modelling of Curves and Surfaces
- To appreciate the knowledge of Finite Element Methods
- To impart knowledge on Virtual Prototyping

UNIT 1: CAD FUNDAMENTALS AND GRAPHICS **8 Hrs.**

Introduction to CAD its benefits, CAD programming, Need and scope of computer aided design, Scan conversion, DDA and Bresenham's Algorithm of line, circle and ellipse.

UNIT 2: GEOMETRIC TRANSFORMATIONS **9 Hrs.**

2D and 3D geometric transformations: Translation, Scaling, Rotation, Reflection, Homogeneous transformations, Orthographic and Affine transformations.

UNIT 3: CURVES AND SURFACES **14 Hrs.**

Parametric representation of synthetic curves: Hermit cubic splines, Bezier curves, B-splines, NURBS, constructive solid geometry, Introduction to Surfaces, Introduction to Reverse Engineering, surface generation using 2D curves/views, Introduction to Virtual prototyping and augmented reality, Case Studies

UNIT 4: FINITE ELEMENT METHOD **14 Hrs.**

Introduction, FEM procedure, Discretization of the Domain, Interpolation Models, Higher Order and Isoparametric Elements, Derivation of Element Matrices, Assembly of Element Matrices, Derivation of System Equations, Numerical Solution, Basic Equations and Solution Procedure, Analysis of Trusses, Beams.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Build** fundamental concepts related to CAD
CO2 - **Apply** algorithms to build CAD entities
CO3 - **Model** 2D and 3D transformations of CAD objects
CO4 - **Examine** 3D views during various transformations
CO5 - **Construct** geometric curves and surfaces
CO6 - **Develop** the fundamentals of finite element method

TEXT/REFERENCE BOOKS

1. Mathematical elements for computer graphics by David F Rogers and J. Adams, 2nd Ed, TMH
2. CAD/CAM Theory & Practice by Ibrahim Zeid, 2nd Edition, Tata Mc Graw Hill, New Delhi
3. The Finite Element Method in Engineering by S. S. Rao, 5th Edition, Butterworth–Heinemann
4. Computer Graphics by Donald Hearn, 2nd Edition, Pearson
5. Curves and Surfaces for Computer Graphics, David Salomon, Springer

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 4 questions (each of 10 Marks)	40 Marks
Part B/ Question: 5 Questions (each of 12 Marks)	60 Marks

20ME307P					Computer Aided Design Lab.		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester	
-	-	2	1	2	25	25	50

COURSE OBJECTIVES

- To apply knowledge of advanced CAD concepts and techniques by using contemporary CAD software.
- To apply basic knowledge of MATLAB in generating algorithms for basic CAD geometric entities.
- To Understand how to use Finite Element Analysis in obtaining solution of mechanical engineering problems

Mathematical Modeling using MATLAB:

1. Generation of line using DDA and Bresenham's algorithms.
2. Generation of circle using mid-point algorithm.
3. Perform a 2D and 3D translation like scaling, reflection and rotation.
4. Exercise problems on generation of Hermite Curves.
5. Exercise problems on generation of Bezier Curves.
6. Exercise problems on generation of B-Spline Curves.

Finite Element Analysis using FE based software:

1. Introduction to ANSYS Mechanical APDL Finite Element Analysis.
2. FEA of structural and thermal problems.
3. Exercise and assignment problems of FEA on 1D and 2D of structural and thermal problems.
4. Exercise and assignment on non-linear analysis of structural problems.

3D Scanner

COURSE OUTCOMES

On completion of the course, student will be able to
CO1 – **Develop** algorithms to generate basic 2D entities on graphic display system.
CO2 - **Apply** the concepts of geometric transformation and solve the problems in 2D and 3D.
CO3 - **Develop** the MATLAB code for generic problems for the line and circle algorithm.
CO4 - **Generate** synthetic curves like Hermite, Bezier and B-spline curves using MATLAB code.
CO5 - **Build** an **understanding** of using Finite element software ANSYS.
CO6 - **Analyze** the real time engineering problems and estimate the physical quantities.

RESOURCES/TEXT/REFERENCE BOOKS

1. Computer Aided Design Lab Manual.
2. http://www.solidworkstutorials.com/introduction-to-solidworks/
3. Pratap, R., 1998. Getting Started with MATLAB 5: A Quick Introduction for Scientists and Engineers. Oxford University Press, Inc.
4. https://sites.ualberta.ca/~wmoussa/AnsysTutorial/

END SEMESTER LAB EXAMINATION

Max. Marks: 25 **Exam Duration: 2 Hrs**

Two problem MATLAB 15 Marks
Viva-Voce/Exercise on FEM 10 Marks

20ME308T					Design for Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the importance of design principles for manufacturability in the context of Industry 4.0
- To understand the importance of design principles for assembly
- To know how to select parameters for reducing the impact on environment

UNIT 1 Introduction to DFM **10 Hrs**

DFM in the context of Industry 4.0; Advantages of applying DFM, General design principles for manufacturability, Strength and mechanical factors, mechanisms selection, Evaluation method, Process capability, Feature tolerances, Geometric tolerances , Assembly limits -Datum features, Tolerance stacks. Factors Influencing Form Design: General requirements of early materials and process selection, Selection of Manufacturing processes, Process capabilities, Selection of materials, Primary process/ materials selection, Systematic selection of processes and materials.

UNIT 2 Design Considerations **10 Hrs.**

Machining Consideration: Design features to facilitate machining , Drills, Milling cutters, keyways, Doweling procedures, Counter sunk screws, Reduction of machined area , Simplification by separation, Simplification by amalgamation, Design for machinability, Design for economy, Design for capability, Design for accessibility, Design for assembly. COMPONENT DESIGN - CASTING CONSIDERATION: Redesign of castings based on parting line considerations, minimizing core requirements, machined holes, Redesign of cast members to obviate cores. Identification of uneconomical design, Modifying the design, Group technology, Computer Applications for DFMA

UNIT 3 Design for Injection molding and Sheet metal working: **10 Hrs.**

Injection molding materials, Molding cycle, Systems, molds, machine size, cycle time, Cost estimation, Insert molding, Design guidelines, Introduction to sheet metalworking, Dedicated Dies and Press working, Press selections, Design Rules.

UNIT 4 Design for Environment **10 Hrs.**

Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines, Applications, Lifecycle assessment: Basic method, AT&T's environmentally responsible product assessment , Weighted sum assessment method, Lifecycle assessment method, Techniques to reduce environmental impact , Design to minimize material usage, Design for disassembly: Design for recyclability, Design for remanufacture, Design for energy efficiency, Design to regulations and standards.

Total (40 Hrs.)

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define and Understand the fundamental priniciples related to DFM.
CO2 - Understand and Apply the principles of DFM
CO3 - Understand and Apply principles of DFA
CO4 - Evaluate and select good designs for Injection molding and Sheet metal working
CO5 - Evaluate a given design for meeting organisation strategies
CO6 - Generate a new design for a given set of organisational requirements.

TEXT/REFERENCE BOOKS

1. Bralla, "Design for Manufacture handbook", McGraw Hill Ltd.
2. Boothroyd, G, Heartz and Nike, "Product Design for Manufacture", Marcel Dekker Newyork.
3. Dixon, John. R, and Corroda Poli, "Engineering Design and Design for Manufacture and Structural Approach", Field Stone Publisher, USA.
4. Fixel, J. "Design for the Environment", McGraw Hill Ltd
5. Kevien Otto and Kristin Wood, "Product Design", Pearson Publication.
6. Harry Peck, "Designing for Manufacturing' –, Pitman Publications.
7. Merhyle F Spotts, "Dimensioning and Tolerancing for Quantity Production", Prentice Hall, Inc. Englewood Cliffs, New Jersey.
8. Kaushik Kumar, Divya Zindani, J. Paulo Davim,Digital Manufacturing and Assembly Systems in Industry 4.0
2019 by CRC Press

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: <Two out of Three full questions> <40> Marks
Part B/Question: < Two out of Three full questions > <40> Marks
Part C/Question: < One out of Two full questions > <20> Marks

20ME308P					Design for Manufacturing Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	---	---	---	50	50	100

COURSE OBJECTIVES

- To educate students in traditional manufacturing processes
- to provide an understanding of how critical dimensional tolerancing is to component cost and performance
- To teach students to think about how each component will be manufactured and assembled in the design phase

List of Experiments

1. Understanding of limits, fits and tolerances
2. Software based design for manufacturing
3. Software based design for assembly
4. Software based feature tolerancing
5. Software based computation of Assembly limits
6. Software based design to minimize material usage
7. Software based design for ergonomics
8. Software based design for machinability
9. Software based design for accessibility

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define and Understand limits, fits and tolerances
CO2 - Understand and Apply the principles of DFM
CO3 - Understand and Apply principles of DFA
CO4 - Evaluate and select good designs based on ergonomics
CO5 - Evaluate a given design based on machinability
CO6 - Generate a new design for a given set of requirements.

TEXT/REFERENCE BOOKS

1. Bralla, “Design for Manufacture handbook”, McGraw Hill Ltd.
2. Boothroyd, G, Heartz and Nike, “Product Design for Manufacture”, Marcel Dekker Newyork.
3. Dixon, John. R, and Corroda Poli, “Engineering Design and Design for Manufacture and Structural Approach”, Field Stone Publisher, USA.
4. Fixel, J. “Design for the Environment”, McGraw Hill Ltd
5. Kevien Otto and Kristin Wood, “Product Design”, Pearson Publication.
6. Harry Peck, “Designing for Manufacturing’ –, Pitman Publications.
7. Merhyle F Spotts, “Dimensioning and Tolerancing for Quantity Production”, Prentice Hall, Inc. Englewood Cliffs, New Jersey.

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50	**Exam Duration: 2Hrs**
Part A: Lab work	25 marks
Part B: Viva Voce	25 Marks

20ME309T					Dynamics and Control of Unmanned Aerial Vehicle					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To get the basic understanding of unmanned aerial vehicles and its applications.
- To understand the kinematics and dynamics of a quadrotor.
- To apply the controls on the quadrotors to achieve desired tasks.
- To evaluate the motion and path planning of a quadrotor.
- To achieve the computer based dynamic simulation of a quadrotor.

UNIT 1 Introduction to UAV **8 Hrs.**

Introduction to unmanned aerial vehicles, History and development of unmanned air vehicle (UAV). Types of UAV's: unmanned aircraft & quadrotors and its applications. Design consideration of quadrotor.

UNIT 2 Kinematics and dynamics of quadrotor **12 Hrs.**

Kinematics of quadcopter - Rotation matrix, Euler angles, transformations, Dynamics of quadcopter – angular velocity, Rigid body displacement, Newton-Euler equation, Quadrotor equation of motion – 2D and 3D.

UNIT 3 Controls, motion and path planning of quadrotor **10 Hrs.**

Control of a 2D-quadcopter model through PID controllers, Control of a 3D-quadcopter model, Motion and trajectory planning of a quadrotor.

UNIT 4 Computer modelling and simulation of quadrotor **10 Hrs.**

Computer simulation - 3D modelling of quadrotor, Import of 2D/3D model into MATLAB/Simulink software. Dynamic simulation and control of quadrotor, Motion and trajectory planning of quadrotor through computer simulation.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Understand** the elementary working of an unmanned aerial vehicle.
CO2 - **Establish** the kinematic relations and Obtain the dynamical formulation of a quadrotor.
CO3 - **Formulate** the governing equation of motion of 2D and 3D quadrotor.
CO4 - **Apply** the PID controls on a quadrotor to Demonstrate the desired attitude/angular controls.
CO5 - **Evaluate** the motion and path planning of a quadrotor.
CO6 - **Utilize** the computer based dynamic simulation and control of a quadrotor model.

TEXT/REFERENCE BOOKS

1. Powers, Caitlin, Daniel Mellinger, and Vijay Kumar. "Quadrotor kinematics and dynamics." Handbook of unmanned aerial vehicles (2015): 307-328.
2. Mejia, Omar D. Lopez, and Jaime Escobar, eds. Aerial Robots: Aerodynamics, Control and Applications. BoD–Books on Demand, 2017.
3. Nonami, Kenzo, et al. Autonomous flying robots: unmanned aerial vehicles and micro aerial vehicles. Springer Science & Business Media, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from unit I, II 50 Marks

Part B/Question: 15 Questions from Unit III 50 Mark

20ME310T					Work Design and Measurement					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To study principles of work study and motion study.
- To study the fundamentals of allowances types and its implementation
- To study of job evaluation, wages and incentives techniques
- To study break-even point analysis to improve the performance

UNIT 1 Work Study and Motion Study **15 Hrs.**

Introduction to Work Study, Historical development, Productivity and Work study, human factors and influence of working conditions in work study. Motion Study; procedure for method study; selection of jobs; recording techniques; micro-motion study; Therbligs; cyclograph and chronocyclograph; principles of motion economy; design of work place layout; analysis in the form of a chart; operation chart; flow process chart; flow diagram; string diagram; man-machine chart; two hand chart; simo chart.

UNIT 2 Work Measurement **10 Hrs.**

Introduction to work measurement, definition, uses, procedure; time study equipment; selection of operator, performance rating, allowances, synthesis, standard data, production interruption study, analytical estimation, work sampling, statistical concepts, confidence limits, number of cycles to be studied; determination of standard time.

UNIT 3 Job evaluation and incentive schemes **10 Hrs.**

Introduction to job evaluation; objectives of job evaluation; job analysis, job description, methods of job evaluation like factor comparison, point system, etc. Job design, psychological aspects of job design. Introduction to ergonomics in the work environment. Wages and incentives, characteristics of a good wage/incentive system, methods of wage payment. Halsey's premium plan, piece rate system.

UNIT 4 **10 Hrs.**

Value Engineering, concept of value; product life cycle, value engineering approaches, job plan, value tests. Introduction to plant layout, importance and relevance of plant layout, various types of plant layout, process layout, product layout, cellular layout, fixed layout; layout algorithms. Layout of service facilities. Types and methods of cost estimation, cost elements, allocation of overheads, break-even point.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define the fundamentals of work study and motion study.

CO2 – Apply the principles of motion study for the analysis of job and reduction of time.

CO3 – Understand time study equipment and performance rating.

CO4 - Evaluate the standard time of the job with different types of allowances.

CO5 - Explain the different types of wages and incentive schemes.

CO6 – Choose the appropriate type of plant layout and apply break-even point analysis for performance improvement in suitable work environment.

TEXT/REFERENCE BOOKS

1. Ralph M. Barnes, Motion and Time Study; John Wiley and Sons.
2. Miles; L. D., Techniques of Value Engineering and Analysis, McGraw Hill.
3. Martand, T., Industrial engineering and production management, S. Chand and company Ltd.
4. ILO, Introduction to Work Study, Universal Publishing Corporation, Bombay
5. Mundel, Motion and Time Study, Prentice Hall of India.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from all units together - each carrying 5 marks 20 Marks

Part B/Question: 2 Questions from each unit each carrying 10 marks 80 Marks

20ME311T					Additive Manufacturing in Industry 4.0					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide fundamentals of additive manufacturing (AM) and Industry 4.0 with recent development and applications
- To understand the basics of Industry 4.0 and its different pillars
- To understand the importance of time compression technologies
- To Realization of Additive manufacturing in the era of Fourth Industrial revolution

UNIT 1 **12 Hrs.**

Additive manufacturing (AM): Overview-Need-Classification of AM processes-AM applications in various Industries, current development in the field of AM, computer aided design for AM, Materials for AM, AM in Industry 4.0.

UNIT 2 **10 Hrs.**

Introduction to Industry 4.0: The Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers and Challenges for Industry 4.0, The Journey so far: Developments in USA, Europe, China and other countries, Comparison of Industry 4.0 Factory and Today's Factory. **Road to Industry 4.0:** Sensing & actuation, connectivity, networking, Internet of Things (IoT), Smart Manufacturing, Smart Devices and Products, Cloud basics.

UNIT 3 **12 Hrs.**

Integration of Additive manufacturing and Industry 4.0

Rapid Manufacturing Process Optimization- Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation.

Software for RP: STL files, overview of solid view, magics, mimics, magics communicator, etc., internet based softwares, collaboration tools.

UNIT 4 **8 Hrs.**

Case studies and Applications: *

Will be finalized as per faculty and student interest on AM in the era of I 4.0

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand fundamentals of Additive manufacturing (AM) with classification of AM processes.
CO2: Apply knowledge of different AM materials in AM.
CO3: Understand the fundaments of Industry 4.0 and its different pillars
CO4: Apply knowledge of technologies associated with I4.
CO5: Explore different software's for AM and I4.0
CO6: Apply case study based learning and create bridge for additive manufacturing in the era of Industry 4.0

TEXT/REFERENCE BOOKS

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.
3. Gilchrist, A. (2016). Industry 4.0: the industrial internet of things. Apress.
4. Schwab, K. (2017). The fourth industrial revolution. Currency.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from each unit, each carrying 10 marks	40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks	60 Marks

20ME312T					Applied Data Analysis and Machine Learning					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn the exploratory data analysis.
- To understand the concept of various statistical distributions.
- To understand the machine learning framework.
- To formulate and implement machine learning methods for real world applications.

UNIT 1 Exploratory Data Analysis **08 Hrs.**

Introduction to various datasets, Histogram and Probability Density Function, Pair Plot,3D Scatter Plot, Box and Whisker Plot, Percentiles and Quantiles, Univariate and Multivariate Analysis.

UNIT 2 Probability and Statistics **12 Hrs.**

Population and Sample, Gaussian and Cumulative Distribution Function, Chi Squared Distribution, Covariance, Pearson Correlation Coefficient, Spearman Rank Correlation Coefficient , Kendall's Rank Correlation., Data Standardization, Data Normalization, Balanced and Imbalanced data set.

UNIT 3 Machine Learning **11 Hrs.**

Introduction, Supervised, Unsupervised learning and semi supervised learning, advantages and disadvantages, regression analysis, feature vector and its application for classification and regression analysis, Performance metrics for evaluation of machine learning methods.

UNIT 4 Machine Learning Methods **14 Hrs.**

Implementation of Linear Regression, Logistic Regression, Naive Bayes, Linear Discriminant Analysis,K-Nearest Neighbour, Artificial Neural Network, Support Vector Machine, Dimensionality Reduction techniques on publically available dataset.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** the basic concept of exploratory data analysis.
CO2: **Estimate** various types of probability functions.
CO3: **Evaluate** various types of data preparation techniques.
CO4: **Analyse** and prepare suitable architecture of machine learning framework.
CO5: **Comprehend** various types of machine learning algorithms.
CO6: **Formulate** and make use of appropriate methods for practical implementations.

TEXT/REFERENCE BOOKS

1. Practical Statistics for Data Scientists: 50 Essential Concepts, O'Reilly Media; first edition (2017)
2. H. Pishro-Nik, Introduction to Probability, Statistics, and Random Processes, Kappa Research (2014)
3. E. Alpaydin, Introduction to Machine Learning, Pearson, third edition (2015)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A : 2 Questions each carrying 5 Marks	10 Marks
Part B : 3 Questions each carrying 10 Marks	30 Marks
Part C : 4 Questions each carrying 15 Marks	60 Marks

20HS301P					Communication Skills – III (Semester V/VI) (Third Year)					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	0	2 hours per week	--	--	--	50	50	100

COURSE OBJECTIVES

- To strengthen the communication skills of professionals to make them ready for the modern workplace.
- To fine tune their professional skills and expertise using communication skills.
- To participate in the life long learning process with confidence and certainty.

UNIT 1 **10 hrs**

- Writing research proposals
- Writing technical projects

UNIT 2 **15 hrs**

- The Art of Presentation
  - *Sapiens: A Brief History of Humankind* (2011), Yuval Noah Harari
  - *Thank You for Being Late: An Optimist's Guide to Thriving in the Age of Accelerations* (2016), Thomas L. Friedman
  - (Presentation in teams of 4 students each, not more than two from the same branch, with a view to promote cross-disciplinary research)

UNIT 3 **5 hrs**

- Uploading portfolios on SlideShare
  - ✓ Uploading Video modules

Max. 30 hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

- CO 1 Demonstrate enhanced communications skills for enhanced team work for a better result.
- CO 2 Apply critical analysis for innovative thinking and well-rounded perspectives in different settings and contexts.
- CO 3 Analysis of situations to identify opportunities for professional and career growth through strong communication skills.
- CO 4 High competence of oral, written and visual communication skills for a workplace ready professional.
- CO 5 Realization and application of communication skills and language processes for multiple perspectives and interdisciplinary approach in profession.
- CO 6Improved communication skills for improved research, organizational, and critical thinking and perspective.

TEXT/REFERENCE BOOKS

1. Kaul, Asha. Business Communication. Delhi: Prentice-Hall of India, 2006.
2. Maley, A. 'Literature in the Language Classroom', The Cambridge Guide to Teaching ESOL, Cambridge University Press, 2001.
3. Richards, Jack C., and Willy A. Renandya, eds. Methodology in Language Teaching: An Anthology of Current Practice. Cambridge University Press, 2002.
4. Sharma, Sangeeta and Binod Mishra. Communication Skills for Engineers and Scientists. New Delhi: PHI Learning Pvt. Ltd., 2009.

Assessment Tool	Marks	Assignments
Lab Work	50	• Business Proposal – 15 • Research Project Proposal – 15 • Reviews on the two books – 20
Lab Exam/Viva	50	• Presentation on the reviews of the two books (Intra Branch) – 15 • Presentation on a technical topic (Inter Branch) – 15 • Slideshare/Video Modules (Prescribed Texts) – 20

Course Structure of B.Tech. in Mechanical Engineering

COURSE STRUCTURE FOR B.TECH. THIRD YEAR (Mechanical Engineering)

SEMESTER VI (Subjects)				B.TECH. THIRD YEAR (Mechanical Engineering)											
Sr. No.	Category Code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
									Theory			Practical		Total Marks
				L	T	P	C	Hrs/wk	CE	MS	ES	CE	ES	
1	PCC	20ME313T	Refrigeration and Air-conditioning	3	0	0	3	3	25	25	50	-	-	100
2	PCC	20ME313P	Refrigeration and Air-conditioning - Lab.	0	0	2	1	2	-	-	-	25	25	50
3	PCC	20ME314T	Machine Design - I	3	0	0	3	3	25	25	50	-	-	100
4	PCC	20ME314P	Machine Design - I - Lab.	0	0	2	1	2	-	-	-	25	25	50
5	PCC	20ME315T	Manufacturing Process - II	3	0	0	3	3	25	25	50	-	-	100
6	PCC	20ME315P	Manufacturing Process - II - Lab.	0	0	2	1	2	-	-	-	25	25	50
7	PCE	20ME3XXT	Professional Core Elective - III	3	0	0	3	3	25	25	50	-	-	100
8	OE	20ME3XXT	Open Elective - IV	3	0	0	3	3	25	25	50	-	-	100
9	PCC	20ME331T	Computational Engineering Laboratory	0	0	4	2	4	-	-	-	25	25	50
10	Project	20TP310	Industrial Training/ IEP (6 weeks-summer break)	0	0	0	2	0	-	-	-	50	50	100
			Total	**15**	**0**	**10**	22	25						

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

Professional Core Elective – III:

Course Code	Course Name	Course Code	Corse Name	Course Code	Course Name
20ME316T	Power Plant Engineering	20ME320T	Rapid Product Development	20ME324T	Production and Operations Management
20ME317T	Compressible Fluid Flow	20ME321T	Mechanical Vibration	20ME325T	Robotics
20ME318T	Industrial Fuel, Combustion and Pollution	20ME322T	Additive Manufacturing	20ME326T	Advanced Thermodynamics
20ME319T	Design of Solar Thermal Systems for Industrial Applications	20ME323T	Heat Exchanger Design	20ME327T	Energy Storage Systems and Application

Open Elective – IV:

Course Code	Course Name	Course Code	Corse Name	Course Code	Course Name
20ME328T	Principles of Finance & costing	20ME329T	Engineering Optimization	20ME330T	Design & Management of MSMEs

20ME313T					Refrigeration and Air-conditioning					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

Course Objectives

- To impart the knowledge of construction, working and analysis of various refrigeration and air-conditioning system
- To evaluate the performance of various refrigeration system and identify its application
- To estimate the cooling/heating load and design the appropriate air-conditioning system

UNIT 1 Air-refrigeration and vapour compression refrigeration system (14L)

Air refrigeration: Introduction to Refrigeration; Necessity and applications; Bell-Coleman cycle, open and dense air systems, simple, boot strap, regenerative, and reduced air refrigeration system, comparison of various air refrigeration systems. Vapour Compression Refrigeration: Working principle and essential components of the plant, simple vapour compression refrigeration cycle - COP, Representation of cycle on T-S and P-h charts - Effects of various parameters on system performance - cycle analysis - Actual cycle, multistage compression system, and their analysis, multi-evaporator system and their analysis, cascade system. Industrial refrigeration system. Refrigerants: Desirable properties of refrigeration's; classification of refrigerants; ozone depletion global warming, secondary refrigerants, future industrial refrigerants, recent development. Heat pump

UNIT 2 Non-conventional refrigeration systems (10L)

Vapour Absorption Refrigeration: working principles; description and working of NH3- H2O system and LiBr- H2O system; three fluid absorption system and its salient features; Steam jet refrigeration system - working principle, basic components and analysis; principle and operation of vortex tube.

UNIT 3 Psychometric properties and process (11L)

Psychometric – Composition of air and its effect on human comfort; psychometric terms – specific humidity, relative humidity percentage humidity and absolute humidity; temperatures – dry bulb, wet bulb and dew point; Psychometric processes: different types of psychometric processes sensible heating and cooling process, Latent heating and cooling process, heating with humidification, cooling with dehumidification, adiabatic cooling; air washer process; contact and bypass factor; apparatus dew pint; condition line; sensible heat factor; Requirement of human comfort.

UNIT 4 Cooling/Heating load calculation, Air Conditioning systems & components design (10L)

Cooling/Heating load calculation for various industrial & commercial applications; Selection of air-conditioning system, requirements of industrial air-conditioning system; Summer, winter and year round air-conditioning system; Air transmission In air conditioning ducts, air conditioning duct design, ventilation for cooling

Total Lecture: 45 Hrs

Course Outcome:

On completion of the course, student will be able to

CO1: Understand the construction and working of various refrigeration & air-conditioning systems and list its applications.
CO2: Analyse the various configuration of vapour compression refrigeration system and evaluate its performance.
CO3: Investigate the performance of different conventional and nonconventional refrigeration systems
CO4: Develop generalized psychometrics of moist air and apply to air-conditioning processes
CO5: Design thermal comfort conditions with proper psychometric processes and evaluate its impact on human comfort, productivity, and health
CO6: Estimate the cooling/heating load for different application and design the associate sub systems

Text/reference books

1. C. P. Arora, Refrigeration and Air Conditioning, Tata McGraw Hill, 2000
2. R.J. Dossat, Principal of refrigeration, John Willey, 1981
3. Manohar Prasad, Refrigeration and Air-conditioning, New age publishers, 2011
4. W.F. Stoker, Refrigeration and Air-conditioning, McGraw-Hill, 2002

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME313P					Refrigeration and Air-conditioning lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

Course Objectives

- Provide the knowledge of construction, working and operation of various refrigeration and air-conditioning equipment
- To measure the performance parameter and evaluate the system performance of various refrigeration and air-conditioning equipment
- To Identify the effect of operating parameters on the system performance

List of Experiments

Experiment 1: To study various air refrigeration system

Experiment 2: Performance test on vapor compression refrigeration system to measure the COP of the system

Experiment 3: Performance test on heat pump system and measure the COP of heat pump during different working condition.

Experiment 4: To study NH_3-H_2O and LiBr-H_2O vapour absorption system

Experiment 5: Performance test on three fluid vapour absorption system and measure COP of the system

Experiment 6: Performance test on Cascade refrigeration system and measure the COP of the system

Experiment 7: Performance test on Vertex tube refrigeration system to measure the cooling and heating capacity of the system

Experiment 8: To Study Psychometric terms and plot it on Psychometric chart

Experiment 9: To carry out various air conditioning process with air conditioner trainer and find out relative process parameter on Psychometric chart

Experiment 10: Performance test on air-conditioning system and measure the cooling capacity and COP of the system

Experiment 11: To estimate the cooling load of Refrigeration and Air-conditioning laboratory

Experiment 12: Performance test on Heat pump system to measure the COP of the system

Course Outcomes

On completion of the course, student will be able to

CO1: Understand the function of different components of refrigeration and air-conditioning system with its construction and working.
CO2: Evaluate the performance of different refrigeration and air-conditioning system.
CO4: Analysed the effect of operating parameters on the performance of refrigeration and air-conditioning system.
CO5: Compare the performance of different system and identify its application
CO6: Estimate the cooling/heating load of any space

Text/reference books

1. C. P. Arora, Refrigeration and Air Conditioning, Tata McGraw Hill, 2000
2. R.J. Dossat, Principal of refrigeration, John Willey, 1981
3. Manohar Prasad, Refrigeration and Air-conditioning, New age publishers, 2011
4. W.F. Stoker, Refrigeration and Air-conditioning, McGraw-Hill, 2002

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 2 Hrs**

Part A: Quiz/Experiment 10 Marks

Part B: Viva 15 Marks

20ME314T					Machine Design - I					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To gain familiarity with the concepts of design procedure under different types of loads
- To be able to design a pressure vessel as per industrial requirements
- To obtain the knowledge of designing power transmission systems
- To attain capability of designing various components of an Engine

UNIT 1 **(12L)**

Design based on deflection and stiffness: Tension, compression and torsion based design, deflection in members, statistically indeterminate design problems, design of compression members, design for eccentric loading, design for shock and impact loading. **Failure resulting from static load:** Stress concentration, theories of failure for ductile and brittle material, contact stress **Failure resulting from variable load:** strain –life relationship, stress-life relationship, endurance limit, fatigue strength, notch sensitivity, torsional fatigue, fluctuating stress characterization, Goodman's line, Soderberg's line, Modified Goodman's line, surface fatigue strength, Design factor in fatigue.

UNIT 2 **(10L)**

Design of Pressure Vessels: Types and applications of pressure vessels, Design of thin and thick cylindrical and spherical shells, Compounding of cylinders, Design of interference joints – press / shrink fitted assemblies, Design of cylinder covers, Cover plates.

UNIT 3 **(10L)**

Design of Power Transmission Systems: Introduction and applications of power transmission systems. Types of power transmission devices, advantages and disadvantages, components of belt drive, mechanism of belt drive, Belt Materials, Types of belts and pulleys and their selection, Stresses in belts, Transmission efficiencies, Design/selection of flat belt drive, design/selection of V-belt drive, Design of Chain drives and wire ropes

UNIT 4 **(10L)**

Design of Engine Parts: Components of I.C. engine, materials for engine components, working conditions, Forces and stresses acting on various engine components, Design of cylinder and cylinder liner, Design of piston, Design of Connecting Rod, Design of crank shafts, Design of crank pins.

Lecture: 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Recall fundamentals of failure of mechanical components related to static loading

CO2: Evaluate the life of component under variable loading

CO3: Solve the problem of cylinder for different thickness.

CO4: Analyze the various stresses in pressure vessels

CO5: Compare different transmission devices such as belt and chain drives

CO6: Design the engine components such as cylinders, piston, connecting rod and crank shaft.

TEXT/REFERENCE BOOKS

1. V. Bhandari, Machine Design, Tata-McGraw Hill Publishers.
2. R. S. khurmi and J. K. Gupta, Machine Design, S Chand Publication
3. C. Sharma and K. Purohit, Design of Machine Elements, PHI Publishers.
4. J. Shigley, C. Mischke, R. Budynas, Mechanical Engineering Design, Tata-McGraw Hill Publishers.
5. R. Juvinall, K. Marshek, Fundamental of Machine Component Design, John Wiley and Sons Publishers.
6. R. Norton, Machine Design: An Integrated Approach, Pearson Education Publishers.
7. S. Kazimi, Solid Mechanics, Tata-McGraw Hill Publishers.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 questions of 2 marks each 16 Marks

Part B/Question: 6 questions of 14 marks each 84 Marks

20ME314P					Machine Design -I Practical		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester	
--	--	2	1	2	**25**	**25**	**50**

COURSE OBJECTIVES

- To define mechanical problem and learn mathematical formulation.
- To learn Matlab coding, CAD modelling and ANSYS software.
- To perform analysis and interpret the results.

PART A: Minor Project

List of Design Problems: Manual design, Computer program and solid model using CREO

1. Design exercise for Cylinder shells
2. Design exercise for Spherical Shells
3. Design exercise for Belts and pulleys
4. Design exercise for Engine cylinder
5. Design exercise for Connecting Rod
6. Design exercise for Crank Shaft and Crank pin
7. Description of standard parts available in market for various assembly of machine

PART B: Major Project

Consist of:

1. Conduct FEA analysis and understand the results. Visit of any one industry identified
2. Manual Design of the major design
3. Preparation of the Computer program for the design (for parametric analysis and optimization)
4. Preparation of the solid model, detail and assembly drawings using software
5. Analysis of the parts using FEA software
6. Preparation of the report

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** and List the programming, modelling and analysis software.
CO2 - **Classify** different types of analysis that can be performed on mechanical components.
CO3 - **Prepare** problem and Solve mathematical equations for simple interdisciplinary problem.
CO4 - Conduct FEA analysis and **analyze** the findings obtain through Matlab and FEA.
CO5 - **Compare** the results obtain using Matlab and ANSYS.
CO6 - **Design** and Develop Matlab code, CAD model and perform analysis for a real life problem of society.

TEXT/REFERENCE BOOKS

1. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford University Press, 2010.
2. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 3rd Edition, Tata McGraw-Hill Education, 2011.
3. Mary K. Thompson & John M. Thompson, ANSYS Mechanical APDL for Finite Element Analysis, 1st Edition, Butterworth-Heinemann, 2017.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs**

Part A : Presentation based on Project 25 Marks
Part B : Viva 25 Marks

20ME315T					Manufacturing Processes - II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide fundamentals of machining and Machine tools.
- To study single point cutting tool with importance of different tool angles.
- To provide knowledge of machining tools with numerical and experimental understanding.
- To understand role of finishing processes in manufacturing.

UNIT 1 Introduction and machine tool drives **12 Hrs.**

Need of machining – classification of machining. Introduction to machine tools and power drives – classification of machine tools. **Single point cutting tool:** Tool geometry– concept of rake and clearance angles –different systems of tool geometry –mechanism of chip formation-essential properties and types of cutting fluids, machinability – failure, life and materials of cutting tools.

UNIT 2 Lathe, Shaping, slotting, planning and broaching machines **12 Hrs.**

Lathe: Principle of working. Various lathe operations – accessories – classification and specification of lathe machines-Tool and job holders in lathes. Numerical and experimental study-effect of process parameters. Shaping, slotting, planning and broaching machines: Kinematic systems – principle of working – classifications, specification and operations performed - machining time calculation.

UNIT 3 Milling, Drilling and boring machines **10 Hrs.**

Kinematic system – principle of working – classifications – specifications – operations performed – accessories – milling cutter – classifications of cutters. Introduction to indexing – methods of indexing – gear cutting methods– twist drill – deep hole drilling machines. Numerical and experimental study-effect of process parameters.

UNIT 4 Grinding and super finishing **8 Hrs.**

Classifications of grinding machines – specifications grinding wheels – mechanism of grinding – different bonds and abrasives–truing and dressing. Super abrasive wheels and their bonds. Purpose and order of super finishing– micro and super finishing methods – characteristics and applications.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand fundamentals of machining and machine tools used in manufacturing.
CO2: Analyze single point cutting tool geometry with role of different tool angels.
CO3: Evaluate role of chip formation and cutting fluid on machining.
CO4: Apply different principles of Lathe machine with machining characteristic in manufacturing.
CO5: Understand fundaments of Milling, drilling and Boring machines and evaluate machining performance.
CO6:Explain grinding and super finishing processes with their characteristics.

TEXT/REFERENCE BOOKS

1. A. B. Chattopadhyay, Machining and Machine Tools, John Wiley & Sons publisher.
2. Geoffrey Boothroyd, Fundamentals of Metal Machining and Machine Tools, CRC press.
3. R.K. Jain and S.C. Gupta, Production Technology.
4. B S Raghuwanshi, Workshop Technology – Vol II.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from each unit, each carrying 10 marks 40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks 60 Marks

20ME315P					Manufacturing Process- II Lab.					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	25	25	50

COURSE OBJECTIVES

- To understand the working principle and operations of conventional machining techniques such as Lathe, Milling, Drilling, Grinding, Shaper and Grinding Machines.
- To prepare a job by using Lathe, Milling, Drilling, Grinding, Shaper and Grinding Machines.
- To understand the working principle and operations of non-conventional machining techniques such as EDM, WEDM and ECM processes.
- To prepare a job by using of non-conventional machining techniques such as EDM, WEDM and ECM processes.

List of Experiment

1. Introduction to the safety aspects of conventional and non-conventional machining operations and Study of specification of machines through different catalogs.
2. A study on Lathe machine and its operations.
3. Prepare a Job of required shape and size on Lathe Machine and analyze the effect of process parameters.
4. Prepare a Job of required shape and size on Milling Machine and analyze the effect of process parameters.
5. Prepare a Job of required shape and size on Drilling Machine and analyze the effect of process parameters.
6. Prepare a Job of required shape and size on Grinding Machine and analyze effect of process parameters.
7. Prepare a Job of required shape and size on Shaping Machine and analyze effect of process parameters.
8. Non- Conventional machining by using RAM-EDM and effect of process parameters
9. Non- Conventional machining by using Wire-EDM and effect of process parameters
10. Non- Conventional machining by using Electrochemical Machining (ECM) and effect of process parameters.

Max. 30 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Define fundamentals and principles of metal cutting to practical applications using conventional machining processes of lathe machines

CO2: Apply principles of metal cutting to practical applications using conventional machining processes of milling machines.

CO3: Analyze the effect of process parameters for conventional machining processes of shaping machines.

CO4: Examine the effect of process parameters for conventional machining processes of drilling machines.

CO5: Determine the effect of process parameters for grinding operations.

CO6: Evaluate the performance of different non-conventional machining processes such as EDM, WEDM and ECM.

TEXT/REFERENCE BOOKS

1. Sharma PC. A Textbook of Production Enginerring. S. Chand Publishing.
2. Hmt, H.M.T. Production technology. Tata McGraw-Hill Education.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz/Experiment	10 Marks
Viva-Voce	15 Marks

20ME316T					Power Plant Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	0	3	25	50	25	-	-	100

COURSE OBJECTIVES

- To give students an overview and basic knowledge of different types of Power Plants, site selection criteria of each one of them.
- Study different types of fuels used for power generation and discussing environmental and safety aspects of power plant operation.
- Understand the construction and working principle of thermal, gas turbine and diesel engine power plants and study of auxiliary supporting systems.
- Basic knowledge of different types of Nuclear power plants including Pressurized water reactor, Boiling water reactor, gas cooled reactor, liquid metal fast breeder reactor.

UNIT 1 **8 Hrs.**

Introduction – Power and energy, classification of sources of energy, fundamentals of thermodynamics, vapour cycles – working principle, merits & de-merits, applications, **Power Plant Planning & Design –** Terminology, load forecasting, site evaluation, economics - cost of electricity, comparison of power plant prices, fuel costs, utility costs, load curves, equipment procurement & construction contracting, economic and financial feasibility.

UNIT 2 **16 Hrs.**

Fuels and Combustion – Introduction, sources and availability of fuels, characteristics of coal, alternate solid fuels, liquid and gaseous fuels – properties, principle of combustion, burners – design consideration, pulverised coal burners, environmental aspects of power generation. **Steam Power Plant** - General layout, fuel handling system, water treatment, Steam generators- classification, accessories & mountings, fluidized bed boilers, steam turbines – types and components, governing and lubrication system, condensers and cooling towers, ash handling, draft and chimney.

UNIT 3 **10 Hrs.**

Gas Turbine Power Plant – Introduction, ideal Brayton cycle, Gas turbine – systems and equipments, modifications – reheat & regenerative cycle, co-generation – combine heat and power, combined cycle – gas & steam power plants. **Diesel Power Plant** – Introduction, thermodynamic Diesel cycle, general layout, equipments and accessories, terminology, fuel system, lubricating oil system, cooling water system, superchargers and turbochargers.

UNIT 4 **10 Hrs.**

Nuclear Power Plant – Introduction to Nuclear Energy, fission and fusion, nuclear reactors – classification, types, construction and working principle, case studies. **Hydro Power Plant** – Need for hydropower and power estimation, Site selection, run off, factors affecting run-off, components of hydropower pant, hydraulic turbines, selection of turbines, hydrograph and flow duration curve.

Total 44 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Select** the suitability of site for a power plant based on load forecasting and **calculate** load factor, capacity factor, average load and peak load of a power plant.

CO2 - **Summarizing** characteristics of different types of fuel used in power plants and **propose** new solutions to curb environmental problems.

CO3 - **Perform** thermodynamic analysis of thermal power plant and **evaluate** plant efficiency

CO4 – Evaluate performance parameters of gas turbine & diesel power plant and compare their thermodynamic performance.

CO5 - **Identify** the need of hydropower and **estimate** the power generation using hydraulic turbines with respect to the available head.

CO6 - **Explain** construction and working principle of different types of nuclear reactors.

TEXT/REFERENCE BOOKS

1. Dipak Sarkar, “Thermal Power Plant – Design and Operation”, Elsevier Publication
2. Black & Veatch, “Power Plant Engineering’’, Springer
3. Stan Kaplan, “Power Plant Characteristics & Cost’’, Nova Science Publisher Inc.
4. F.T.Morse, “Power Plant Engineeing”, Affiliated East West Press Pvt. Ltd.
5. E.L.Vakil, “Power Plant Technology”, McGraw Hill Publication
6. Gilberto Francisco, “Thermal Power Plant Performance Analysis”, Springer series in Reliability Engineering.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

10 Questions each of 10 marks from above units with appropriate marks distribution among designed Course Outcomes (COs) 100 Marks

20ME317T					Compressible Fluid Flow					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To get the understanding of compressible fluid flow.
- To apply thermodynamic relations in a compressible flow.
- To evaluate the change in pressure, density and temperature for flow through a normal shock.
- To analyse the compressible flow in a duct with heat transfer and with friction.

UNIT 1 INTRODUCTION TO COMPRESSIBLE FLUID FLOW **10 Hrs.**

Review of fluid flow and thermodynamics; Differences between compressible and incompressible flow, Ideal gas, speed of sound, Mach number, Effect of Mach number on compressibility, Entropy relations.

UNIT 2 ISENTROPIC DUCT FLOW OF AN IDEAL GAS **10 Hrs.**

Adiabatic and isentropic flow of perfect gas, Isentropic relations; One-dimensional compressible adiabatic duct flow, critical properties; Converging nozzles, choking, Area-Velocity relation, converging-diverging nozzles, rocket nozzles.

UNIT 3 NORMAL SHOCKS **10 Hrs.**

Normal shocks: Normal shocks in converging-diverging nozzles, Property changes across shocks, Normal Shock on T-S diagram, Prandtl-Meyer relations, Fanno and Rayleigh lines, and Rankine- Hugoniot Relation, Moving normal shocks, explosions and blast waves, piston-driven flow in pipes, expansion waves, reflecting shocks, x-t diagrams.

UNIT 4 RAYLEIGH AND FANNO FLOW IN A DUCT **10 Hrs.**

Flow through constant area duct with heat transfer - Rayleigh flow and equations, Rayleigh line on h-s, P-v diagram and T-s diagrams, choked Rayleigh flow, Fanno flow - Flow in a constant area duct with friction, choked Fanno flow. 2D compressible flow - Oblique shocks, compression waves, reflecting oblique shocks, expansion waves, and supersonic wings.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand and **analyse** compressible and incompressible fluid flow.
CO2: Apply the basic thermodynamic relations in compressible fluid flows.
CO3: Evaluate the change in properties across the normal shocks.
CO4: Comprehend the flow through duct with heat transfer.
CO5: Understand the flow through duct with friction.
CO6: Recognize several characteristics of the two-dimensional compressible fluid flows.

TEXT/REFERENCE BOOKS

1. Anderson, John David. Modern compressible flow: with historical perspective. Vol. 12. New York: McGraw-Hill, 1990.
2. Oosthuizen, Patrick H., and William E. Carscallen. Introduction to compressible fluid flow. CRC press, 2013.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from unit I, II and III 25 Marks

Part B/Question: 15 Questions from Unit IV 75 Mark

20ME318T					Industrial Fuel, Combustion and Pollution					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand types of fuels and their characteristics, and combustion systems with emphasis on engineering applications.
- To impart knowledge on combustion characteristics.
- To understand formation of combustion generated air pollutants, their effects of health and environment and different methods to reduce air pollution

UNIT 1 INDUSTRIAL FUELS **10 Hrs.**

Fuels : Energy scenario- national and world, types of fuels - sources of fuels - properties of fuels - fuel analysis - heating values - proximate analysis and ultimate analysis - alternative fuels

UNIT 2 THERMODYNAMICS AND THERMOCHEMISTRY **12 Hrs.**

Thermodynamics of Combustion: Thermodynamics properties, Laws of thermodynamics, Stoichiometry, Thermochemistry, adiabatic temperature, chemical equilibrium.

Chemistry of Combustion: Basic Reaction Kinetics, Elementary reactions, Chain reactions, Multistep reactions, simplification of reaction mechanism, Global kinetics.

UNIT 3 COMBUSTION ANALYSIS **12 Hrs.**

Physics of Combustion: Fundamental laws of transport phenomena, Conservations Equations, Transport in Turbulent Flow. **Premixed Flame:** One dimensional combustion wave, Laminar premixed flame, Burning velocity measurement methods, Effects of chemical and physical variables on Burning velocity, Flame extinction, Ignition, Flame stabilizations, Turbulent Premixed flame. **Diffusion Flame:** Gaseous Jet diffusion flame, Liquid fuel combustion, Atomization, Spray Combustion, Solid fuel combustion.

UNIT 4 COMBUSTION APPLIANCES AND POLLUTION **11 Hrs.**

Combustion Appliances: Furnaces - burners - fluidized bed combustion. Products of combustion: formation of NOx, SOx, COx, etc. during combustion. Pollution and environment: Atmosphere, Chemical Emission from combustion, global warming - depletion of ozone layer - health and safety issues - methods for emission and pollution control - use of alternative energy sources

Max. 45 Hrs.

COURSE OUTCOMES (CO's):

On completion of the course, student will be able to

CO1: Identify types of fuels based on its properties and industrial application.
CO2: Analyze the kinetic mechanism involved in combustion and chemical reaction.
CO3: Classify between diffusion and premixed flame and their utilization in combustion devices.
CO4: Apply principles of combustion kinetic principles for combustion analysis of various types of fuels.
CO5: Understand the formation of pollutants from hydrocarbon combustion.
CO6: Examine effect of pollution on health and environment, use appropriate methods for emission and pollution control

TEXT/REFERENCE BOOKS

1. D. P. Mishra, Fundamentals of Combustion, PHI Learning Private Limited, 2007.
2. Kuo K.K."Principles of Combustion" John Wiley and Sons, 2005.
3. Strehlow R A., "Fundamentals of combustion" McGraw Hill Book Company, 1984.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

10 Questions each of 10 marks from above units with appropriate marks distribution among designed Course Outcomes (COs) 100 Marks

20ME319T					Design of Solar Thermal Systems for Industrial Applications					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To introduce and define the basics concept of solar radiation modelling.
- To familiarize the construction and working principles of non-concentrated and concentrated collectors.
- To enable the students to understand the details about the TES systems.
- To demonstrate the working and calculations involved in design and analysis of heating and cooling systems for Industrial applications.

UNIT 1 Fundamentals of solar Radiation **8 Hrs.**

Thermal radiation concepts; Sun-Earth geometric relationship; Extraterrestrial and terrestrial radiation, Instrumentation and measurement of solar radiation; Mapping with satellite data. Radiative properties, selective surfaces. Use of EES and TRNSYS tools for problem solving.

UNIT 2 Solar thermal collectors **12 Hrs.**

Classification and Industrial applications; Flat plate (liquid and air) and tubular collectors; PCM assisted Flat plate Collectors; Concentrating Collectors: PTC, Compound Curvature, Central receiver, Fresnel reflectors, Tracking; Construction, Thermal analysis and performance parameters, estimation of losses, collector efficiency and collector heat removal factor, testing procedures.

UNIT 3 Solar assisted heating systems **12 Hrs.**

Air and Liquid based solar heating systems: load calculations, physical configuration and mechanical components, circulation and control; Modelling and design: f-Chart, long-term performance calculation; Solar Industrial Process Heat (SIPH) systems: case studies for Textile and milk processing industries. Solar heating economics. Design and Integration of solar heating systems.

UNIT 4 Solar assisted cooling and refrigeration systems **12 Hrs.**

Active solar Cooling Systems: Vapour Compression refrigeration, Vapour absorption cooling, Vapour adsorption cooling, Non-conventional cooling; Case studies on active solar cooling, **Passive Cooling Systems:** PCM assisted cooling and thermal management of buildings, Application of storage for thermal management and battery cooling; Case studies on passive solar cooling, Design and Integration of solar cooling systems.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define and apply the "fundamentals terminologies" used in solar radiation.
CO2- Understand and explain the construction and working of solar collectors
CO3 - Design and analyze the solar thermal collectors
CO4 - Examine the performance of solar heating systems for industrial applications
CO5 - Design and integration of solar heating systems for various applications
CO6 - Compile the information solar air conditioning and refrigeration systems

TEXT/REFERENCE BOOKS

1. Solar Energy by S P Sukhatme and J K Nayak, Mc Graw Hill
2. Principles of Solar Energy by D Yogi Goswami, CRC Press
3. Solar Refrigeration and Air Conditioning by S.C. Kaushik
4. Solar Engineering of Thermal Processes by Duffie and Backman

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Unit 1/Question: Question 1 with subsections(with internal choice)	20 Marks
Unit 2/Question: Question 2 with subsections(with internal choice)	20 Marks
Unit 3/Question: Question 3 with subsections(with internal choice)	30 Marks
Unit 4/Question: Question 4 with subsections(with internal choice)	30 Marks

20ME320T					Rapid Product Development					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To gain knowledge of Product Development
- To gain an insight Rapid Prototyping technologies
- To gain the knowledge of pre and post processing techniques during rapid product development
- To gain the knowledge of Rapid Tooling, use of Reverse Engineering for product development

UNIT 1 Introduction: 11 Hrs.

CAD-CAM and its integration, Rapid Prototyping (RP) Defined, Product development and its relationship. **AM process chain:** Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing. Classification of AM processes: Liquid polymer system, discrete particle system, molten material systems, solid sheet system. Process chain for Rapid Prototyping, Reverse Engineering and CAD model, Digitizing Techniques: Mechanical Contact, Optical Non-contact, Data interface STL interface, data generation, Manipulation, Open files, Repair of STL files, Alternative RP interfaces.

UNIT 2 Part orientation and support generation: 10 Hrs.

Factors affecting part orientation, support structure design, Automatic support structure generation. Model Slicing and Contour Data organization: Model slicing and skin contour determination, Identification of external and internal contours, Contour data organization, Direct and adaptive slicing: Identification of peak features, Adaptive layer thickness determination, Skin contour computation, Tool path generation

UNIT 3 Part Building and Post Processing 10 Hrs.

Recoating, parameters affecting part building time, part quality. Part removal, finishing, curing. Other issues: Shrinkage, Swelling, Curl and distortion, Surface Deviation and accuracy, Build Style Decisions

UNIT 4 Rapid Tooling and Future Directions 11Hrs.

Rapid Tooling and Manufacturing: Classification of RT Routes, RP of Patterns, Indirect RT: Indirect method for Soft and Bridge Tooling, Indirect method, Direct RT: Direct RT method for Soft and Bridge Tooling, Direct method for Production Tooling, Future Directions of AM: Introduction, new types of products and employment.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Comprehend** various types of rapid prototyping/3D printing techniques
CO2 - Error **estimation** in STL files/tessellation algorithms
CO3 - **Examine** the important factors affecting the final product accuracy and precision
CO4 - **Comprehend** the product development cycle, RT processes and reverse engineering solutions
CO5 - **Evaluate** the efficacy of the data processing techniques for 3D model reconstruction
CO6 - **Understand** the working principles of various 3D printing machines

TEXT/REFERENCE BOOKS

1. Jacobs, PF (Ed), Rapid Prototyping and Manufacturing, Society of Manuf. Engrs.
2. Chua C. K. and L. K. Fai, Rapid Prototyping: Principles and Applications in Manufacturing.
3. Gibson, I. (Ed.), Software Solutions for Rapid Prototyping, Professional Engineering Publications, UK

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 5 Questions (8 Marks each)	40 Marks
Part B/Question: 5 Questions (12 Marks each)	60 Marks

20ME321T					Mechanical Vibrations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn theory of vibrations and characterize longitudinal, transverse and torsional vibration.
- To formulate the equation of motion for single and multi-degree of freedom systems.
- To formulate initial and boundary conditions for continuous system.
- To design, analyze and interpret the significance of vibration isolators.

UNIT 1 Introduction **10 Hrs.**

Review of Single Degree of Undamped, Damped and Forced Vibration. Two Degree of Freedom System: Mode Shapes, Eigen Values and Eigen Vectors, Static and Dynamic Coupling, Semi-Definite System, Double Pendulum, Lagrange's Methods etc.

UNIT 2 Multi Degree of Freedom System **11 Hrs.**

Derivation of Equations of Motions, Longitudinal Vibration, Torsional Vibration, Influence Coefficient, General Equation of Motion in Matrix Form. Eigen Value Problem, Solution of Eigen Value Problem. Matrix Method, Matrix Inversion Method, Stodola's Method and Holzer's Method.

UNIT 3 Continuous Systems **10Hrs.**

Formulation of Initial Conditions and Boundary Conditions, Derivation of Longitudinal, Transverse and Torsional Vibrations of Shafts. Determination of Natural Frequencies.

UNIT 4 Vibration Control and Measurement **11 Hrs.**

Vibration Control and Measurement: Vibration Isolators, Vibration Isolation with Rigid and Flexible Foundations, Active Vibration Control, Use of Vibration Absorbers, Vibration Pickups, Vibration Exciters, Signal Analysis, Dynamic Testing of Machines.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Recall** the basic concept of vibration and able to differentiate between damped and undamped vibrations.
CO2: **Analyze** and understand single and two degree of freedom system.
CO3: **Formulate** equation of motions of multi degree freedom system.
CO4: **Compare** various methods and interpret the results.
CO5: **Construct** equations of motion for continuous system.
CO6: **Identify** and illustrate the practical applications of vibration absorbers, isolators and exciters.

TEXT/REFERENCE BOOKS

1. S.S. Rao, Mechanical Vibrations, Pearson Education, Sixth edition (2018)
2. W.T. Thomas, Theory of Vibration with Applications, Pearson, fifth edition (2008)
3. L. Meirovitch, Fundamentals of Vibrations, Waveland Pr, first edition (2010)
4. S.G. Kelly, Schaum's Outline of Mechanical Vibrations, McGraw-Hill, first edition (1996)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A : 6 Questions each carrying 5 Marks 30 Marks
Part B : 7 Questions each carrying 10 Marks 70 Marks

20ME22T					Additive Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide fundamentals of additive manufacturing (AM) with recent development and applications
- To study role of CAD models and CAM programming in AM with Reverse engineering.
- To provide knowledge of different AM processes for various materials based on ASTM standards.
- To develop experimental based learning with case study related to AM processes.

UNIT 1 Introduction to additive manufacturing (AM) **10 Hrs.**

Overview – History – Need- Classification of AM processes- fundamental engineering aspects. **Applications of AM:** AM applications in various Industries. AM in Industry 4.0, current development in the field of AM.

UNIT 2 CAD for AM **10 Hrs.**

CAD model preparation – Part orientation and support generation – Model slicing –Tool path generation (preparatory (G) and miscellaneous (M) code generation) – Softwares for AM Technology. STL file generation, Reverse Engineering, 3D scanning.

UNIT 3 AM Processes **14 Hrs.**

Fused deposition modelling (FDM)- Principle, process, advantages and applications Stereolithography (SLA)-Binder Jetting-Material jetting-Powder bed fusion AM processes involving sintering and melting- Principle, process, advantages and applications-Directed energy deposition-Sheet lamination: Principle, process, advantages and applications

UNIT 4 Material Science Aspects and case study **8 Hrs.**

Different materials used in AM- polymers, metals, multiple materials, multifunctional and graded materials. A case study based on experimental development of 3 D components.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand fundamentals of Additive manufacturing (AM) with classification of AM process.
CO2: Apply various designing and slicing techniques that enable AM and create programming for tool path.
CO3: Understand fundamentals of polymer material based AM processes.
CO4: Analyze the characteristics of Powder based AM process.
C05: Explain different materials used for building three dimensional AM components.
CO6: Create AM components by applying fundamental knowledge of different AM process.

TEXT/REFERENCE BOOKS

1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer, 2010.
2. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: Principles and applications, 3rd Edition, World Scientific, 2010.
3. Gebhardt A., "Rapid prototyping", Hanser Gardener Publications, 2003.
4. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, Rapid manufacturing, Hanser Publishers, 2011.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from each unit, each carrying 10 marks 40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks 60 Marks

20ME323T					Heat Exchanger Design					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of construction, working and application of various heat exchangers
- To perform the thermal and hydraulic design of various heat exchangers
- To estimate the effect of geometric and operating parameters on the performance of heat exchangers

UNIT 1 Basic of Heat Exchanger Design (10L)

Classification of heat exchanger, selection of heat exchanger, review of LMTD & e-NTU method, multi-pass and cross flow heat exchanger, fouling, cleanliness factor, over surface design, techniques to control fouling, additives, rating and sizing problems, enhancement of heat transfer, performance evaluation of heat transfer enhancement technique.

UNIT 2 Shell and Tube Heat Exchanger Design (12L)

Basic components of various STHE, TEMA standard, Classification as per TEMA standard, Thermal Design Theory for shell and tube heat exchanger, as per Kern and Bell-Delaware method, hydraulic design of shell and tube heat exchanger as per Kern method, Bell-Delaware method for Shell and tube heat exchanger design, introduction to HTRI software for STHE design

UNIT 3 Compact heat exchanger design (10L)

Thermal design of plate-fin heat exchanger, fin and tube heat exchanger and plate heat exchanger, Estimation of pressure drop and hydraulic design of plate-fin, fin and tube, and plate heat exchange. Effect of geometric parameters and operating parameters on performance of heat exchanger. Design of double pipe heat exchangers

UNIT 4 Regenerative heat exchanger design (10L)

Assumptions for Regenerator Heat Transfer Analysis, Λ-Π method for regenerator design, balance and symmetric regenerator design, unbalanced and unsymmetrical regenerator design, Influence of Matrix Material, Size, and Arrangement, Influence of longitudinal and transverse heat conduction.

Lecture: 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Enlist the types, construction, main parts, working and applications of various heat exchangers.
CO2: Perform the thermal design of shell and tube heat exchangers.
CO3: Analysed the hydraulic design of shell and tube heat exchanger through various design methodology
CO4: Design the plate-fin and fin-tube heat exchanger and analysed its thermal and hydraulic performance.
CO5: Execute the plate heat exchanger and double pipe heat exchanger design and evaluate its performance.
CO6: Perform the regenerative heat exchanger design and evaluate its performance

TEXT/REFERENCE BOOKS

1. R.K.Shah, P. Sekulic, Fundamentals of Heat Exchanger Design, John Willey
2. Sadik Kakac, Hongtan Liu, Heat exchanger-selection, rating and thermal design, CRC press
3. A.P. Frass, Heat exchanger design, Willey
4. Eric M. Smith, Advances in thermal design of heat exchangers, Willey.
5. W.M. Kays, A.L. London, Compact heat exchangers
6. VK Patel, VJ Savsani, MA Twahid, Thermal system design optimization, Springer Nature

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice 100 Marks

20ME324T					Production and Operations Management					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To study significance on management of production operations.
- To study the importance of forecasting and various techniques of forecasting
- To apply fundaments of inventory management
- To develop skills of material requirement planning and project management
- To evaluate various waiting line models, analysis of various queues and measuring queue performance

UNIT 1 Forecasting and Inventory **10 Hrs.**

Operations Management: Introduction, Operations Management and Strategy, Tools for Implementation of Operations.

Forecasting: Introduction to Operations Management, operations strategy. Forecasting, time series methods of forecasting, causal methods of forecasting, measures of error, qualitative forecasting. Inventory management, inventory costs, the basic EOQ model, EOQ with gradual replenishment, price break models, reorder point, safety stock, the Newsboy problem.

UNIT 2 Material Requirements and Planning **12 Hrs.**

Material Requirements Planning (MRP), components of MRP, MRP logic, lot sizing in MRP systems (LFL, EOQ, POQ, LTC, LUC, etc.), introduction to ERP systems. Operations scheduling, loading, sequencing methods (SPT, EDD, Moore's method, Johnson's method, etc.). Introduction to project management, Gantt charts, CPM, Activity on arrow /Activity on node networks, concept of slack, the critical path, probabilistic time estimates, project crashing.

UNIT 3 Service Processes **10 Hrs.**

Waiting line models, various types of queues (M/M/1. M/D/1, M/G/1, M/M/S, etc.), measures of queue performance, management of waiting lines. Introduction to facility planning, the facility location problem, factors influencing facility location, facility location models, process layouts, layout methods, computerized algorithms for facility layout, product layouts, fixed position layouts, cellular layouts, layout of service facilities.

UNIT 4 Quality Management **10 Hrs.**

Introduction to quality management, cost of quality, quality management systems, concepts of TQM, quality tools, process capability, concept of six sigma, quality tools, control charts ($\bar{X}$ and R charts, p-chart, np-chart, c chart), acceptance sampling, AQL, LTPD, OC curves. Lean manufacturing, JIT, the Toyota Production System, waste elimination, push vs. pull systems, use of kanban.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define the fundamentals of operations managements.
CO2 - Apply the principles of forecasting and inventory management.
CO3 - Estimate cost and quantity of orders by materials requirements and planning techniques.
CO4 – Analyze operations by using operations scheduling, Gantt charts and critical path methods.
CO5 - Evaluate various waiting line models, analysis of various queues and measuring queue performance
CO6 – Understand the concepts of quality management, six sigma and lean manufacturing.

TEXT/REFERENCE BOOKS

1. Chase, R. B., Ravi Shankar, Jacobs, F. R. and Aquilano, N. J., Operations & Supply Management, Tata McGraw Hill.
2. Buffa, E. S. and Sarin, R., Modern, Production and Operations Management, John Wiley.
3. Martand Telsang, Industrial engineering and production management.
4. N. G. Nair, Production and operations management, Tata McGraw hill publishing company

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from all units together - each carrying 5 marks	20 Marks
Part B/Question: 2 Questions from each unit each carrying 10 marks	80 Marks

20ME325T					Robotics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the basic terminology and interdisciplinary facet of robotics.
- To perform the kinematic and dynamic modelling of different types of robots.
- To learn the basic of programming language of robotics.
- To study the various industrial application of robots from the perspective of Industry 4.0.

UNIT 1 Introduction **10 Hrs.**

Classification of robots, basic root components, robot anatomy, manipulator end effectors, controller, power unit, sensing devices, specification of robot systems, accuracy precision and repeatability, work envelop, grippers. Co-ordinate Systems: local frame and global frame, representation, transformations, wrist analysis.

UNIT 2 Kinematics and Dynamics **14 Hrs.**

Parameters of robot link, formulation of D-H matrix, Analysis of different types of robots with different degrees of freedom, inverse kinematics, Dynamic analysis. Different trajectories and its analysis, motion planning, trajectory planning and control.

UNIT 3 Remote Sensing Devices **08 Hrs.**

Position, velocity and acceleration sensors, proximity and range sensors, touch and slip sensors, tactile sensors, force sensors and torque sensors. Robotic vision system: imaging components, picture coding, object recognition, training and vision systems, review of existing vision systems.

UNIT 4 Robotics Programming and Industrial Applications **12 Hrs.**

Methods of robot programming, types of programming, robotics programming languages, artificial intelligence. Non-Industrial Robots: Technologies involved with Domestic Robots, Humanoids, Nature Exploration Robot and other futuristic design. Industry 4.0: Technologies involved, Implementation and Potential.

Max. 44 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** the concept of kinematics and dynamics of rigid body motion.
CO2 - **Classify** the robots and to understand the various subcomponents of industrial manipulator.
CO3 - **Prepare** the Kinematic and Dynamic Model for different types of Industrial Manipulator.
CO4 - **Compare** the suitability of Robots in industrial applications and newer technologies associated with them.
CO5 - **Evaluate** the trajectory of industrial manipulator considering all the motion and forces.
CO6 - **Construct** a program using a robotic programming language for industrial manipulator.

TEXT/REFERENCE BOOKS

1. Robert J. Schiling, Fundamentals of Robotics Analysis and control, PHI publishers, 1996.
2. John J. Craig, Introduction to Robotics: Mechanics and Control, 3rd Edition, Pearson, 2004.
3. R K Mittal and I J Nagrath, Robotics and Control, TMH Edu. Pvt. Ltd., 2003.
4. Groover, Weiss Nagel and Odrey, Industrial robotics, 1st Edition, TMH Edu. Pvt. Ltd., 2008.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A-6 Questions: 5 Marks each	30 Marks
Part B-4 Questions: 10 Marks each	40 Marks
Part C-2 Questions: 15 Marks each	30 Marks

20ME326T					Advanced Thermodynamics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand and apply the thermodynamic laws to engineering thermodynamic systems.
- To perform analysis of thermodynamic cycles and thermodynamics systems.
- To understand, apply the principles of Equilibrium and non-equilibrium thermodynamics
- To understand the microscopic and macroscopic perspective of entropy and exergy.

UNIT 1 Elements of classical thermodynamics (8)

Recapitulation of fundamentals: Basic definition and concepts; The basic laws of Thermodynamics, Entropy flow and enropy production, 3rd law of Thermodynamics - **Thermodynamic Relations**: Evaluation of thermodynamic properties from an equation of state. Helmholtz and Gibbs functions; Maxwell's relations; Enthalpy, entropy, internal energy, and specific heat relations; Clausius-Clapeyron's equation; Applications to ideal and real gases. Joule-Thomson coefficient. **Ideal Gas Mixtures:** Dalton's law of additive pressures, Amagat's law of additive volumes, evaluation of properties. Analysis of various processes. Gas-Vapour mixtures, Psychrometry properties and simple psychrometric process. Non ideal mixtures: Partial molal properties, fugacity of a component in a mixture, changes in property on mixing, free energy of mixing, concept of an ideal solution, conditions of phase equilibrium , Gibbs phase rule.

UNIT 2 Thermodynamics of Reactive Systems (8)

Thermodynamics of Reactive Systems: First law analysis of reactive system; Internal energy and enthalpy of reaction; Enthalpy of formation; Second law applied to a reactive system. Application of reactive thermodynamics to Combustion, Fuel-cell-ion-exchange-membrane

UNIT 3 Advance analysis of Thermodynamic cycles (11)

Gas Power Cycles: Air standard cycles; Carnot, Otto, Diesel, Dual and Stirling cycles, p-v and T -s diagrams, description, efficiencies and mean effective pressures. Comparison of Otto and Diesel cycles. Gas turbine (Brayton) cycle; description and analysis. Regenerative gas turbine cycle. Inter-cooling and reheating in gas turbine cycles, combined cycles. **Vapor Power Cycles**: Carnot vapor power cycle, drawbacks as a reference cycle. Simple Rankine cycle; description, T-s diagram, analysis for performance. Comparison of Carnot and Rankine cycles. Rankine cycle performance analysis. Actual vapour power cycles. Ideal and practical regenerative Rankine cycles, open and closed feed water heaters. Reheat Rankine cycle. Refrigeration Cycles

UNIT 4 Modern thermodynamics (13)

Statistical Thermodynamics: Introduction to statistical methods for evaluating thermodynamic and transport properties. Elements of quantum mechanics, statistical mechanics and kinetic theory. **Non Equilibrium Thermodynamics:** Onsager relations and its application to systems with transport of heat, mass and charge. Entropy production ad entropy flow, thermodynamic forces and flux **Exergy Analysis:** Lost available work referred to heat engine cycle, refrigeration cycle, heat pump cycle, non-flow and steady flow processes, Mechanism of exergy destruction, Exergetic efficiency – **Advanced exergetic analysis**: Approaches for splitting the exergy destruction into endogenous and exogenous parts - **Thermoecomics**

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Apply first and second law analysis to open and closed systems
CO2: Understand and apply thermodynamics relations and laws to equilibrium/non-equilibrium systems.
CO3: Apply equations of state to make property calculations of Ideal/non-ideal /real gases;
CO4: To understand, develop and co-rellate microscopic and macroscopic viewpoint/framework of entropy/exergy.
CO5: To apply principles of equilibrium and non-equilibrium thermodynamics for thermodynamics systems (both reactive and non-reactive).
CO6: Able to apply principles of statistical thermodynamics and non-equilibrium thermodynamics of various thermal system.

TEXT/REFERENCE BOOKS

1. Thermodynamics: an Engineering Approach, Y.A.Cengal and M.A.Boles, McGraw Hill (Fifth edition).
2. A. Bejan, Advanced Engineering Thermodynamics, 3rd edition, John Wiley and sons, 2006.
3. M.J.Moran and H.N.Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley and Sons.
4. Modern thermodynamics: from heat engines to dissipative structures, Kondepudi, Dilip, and Ilya Prigogine. ,Wiley & Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Four questions (One from each unit) 40 Marks
Part B/Question: Four questions (One from each unit) 60 Marks

20ME327T					Energy Storage Systems and Application					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide an insight into the various modes of energy storage
- Discuss the scientific principles underpinning the operation of energy storage systems
- To impart knowledge on construction, working principle and performance analysis of electrochemical, electric and thermal storage systems
- To provide problem solving skills in energy storage engineering and apply them to achieve energy conservation

UNIT 1: INTRODUCTION TO ENERGY STORAGE (10L)

Different modes of energy storage and their status; Potential energy and Pumped hydro storage; KE and Compressed gas system: flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photochemical, bio-chemical, Superconducting Magnet Energy Storage (SMES) systems.

UNIT 2: THERMAL AND ELECTROCHEMICAL ENERGY STORAGE SYSTEMS (12L)

Thermal Storage: Classification; SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers, Phase Change Materials (PCMs); Selection criteria of PCMs; solar thermal LHTE systems. Electrochemical Storage: Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), Batteries- primary, secondary, Lithium; Solid-state and molten solvent batteries; Lead acid batteries; Nickel Cadmium batteries; Advanced batteries, Role of carbon nano-tubes in electrodes.

UNIT 3: ENERGY STORAGE SYSTEM INTEGRATION (10L)

Basics of optimization; Energy storage system optimization; Integration of Energy Storage Systems within buildings; Energy storage examples to resolve intermittency in solar applications and calculations; Case studies

UNIT 4: ENERGY STORAGE APPLICATIONS (12L)

Constant temperature solar water heating for swimming pools and process heating; Constant temperature crop drying; Temperature regulation and control in Buildings; Temperature control of PV modules; Thermal Regulation for Electronic circuits; Economics;

[Total : 44 L]

COURSE OUTCOMES

CO1: **Identify** various means of energy storage and **demonstrate knowledge** on modes of energy storage
CO2: **Impart knowledge** on thermal energy storage systems to **compare and select** sensible and latent heat storage systems for a given application
CO3: **Demonstrate knowledge** on the storage behaviour in electro chemical systems and **identify** the parameters affecting their performance
CO4: **Demonstrate** an **understanding** of electrical energy storage systems and **evaluate** their performance parameters.
CO5: **Develop problem solving** skills in energy storage engineering as a means of resolving the intermittency of renewable energy sources such and solar.
CO6: **Apply knowledge** to **design** and **develop** innovative energy efficiency solutions using energy storage

TEXT/REFERENCE BOOKS

1. Ibrahim Dincer and Mark A Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley and Sons 2011.
2. Luisa F.Cabeza. “Advances in thermal energy storage systems”, Woodhead publications 2014.
3. James Larminie and Andrew Dicks, “Fuel cell systems Explained”, Wiley Publications, 2003.
4. Ru-shiliu, Leizhang, Xueliang sun, “Electrochemical technologies for energy storage and conversion”, Wiley Publications, 2012.
5. Yves Brunet., “Energy storage”, Wiley publications, 2013.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME328T					Principles of Finance & costing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the basic concepts and processes used to determine product costs,
- To be able to analyze and evaluate information for cost ascertainment, planning, control and decision making, and
- Explain the financial goal of a firm.
- To be able to pin point the weak area through analysis & apply principles to evaluate investment 4 opportunities.
- Apply various capital budgeting techniques to evaluate investment projects

UNIT 1 Concept ; scope& application of financial -costing & management accounting 10 Hrs.

Introduction to cost accounting, relationship between financial accounting and cost accounting, cost concepts and costing methods, overview of cost management accounting, various cost concepts, direct expenses & overheads, unit costing, tools and techniques, job and batch costing, activity based costing.

UNIT 2 Costing & Management accounting methods & its applications 12 Hrs.

Estimation of effort and cost for various manufacturing processes. Costing methods: operating costing, process costing and joint costing and by-product costing. Management applications: marginal (variable) costing and CVP analysis, decisions involving short-run alternative choices, pricing decisions. Planning, control and decision making: budgeting and budgetary control systems, variance analysis.

UNIT 3 Investment analysis & shareholder value maximization 10 Hrs.

Understanding the meaning of Financial Management, financial system, time value of money, basics of risks and returns, cost of capital, concepts of time value, compounding and discounting, annuities. Techniques of capital budgeting, NPV, IRR and other methods. Estimation of cash flows, risk analysis in capital budgeting

UNIT 4 Working capital assessment & management 8 Hrs.

Principles of Working Capital Management, Various Approaches, Estimation of Working Capital, Management of Components of Working Capital; Cash, receivables, inventory. Working capital financing, sources of working capital finance.

Max. 40 Hrs.

COURSE OUTCOMES

CO1 - Define and understand financial management/cost accounting concepts
CO2 - Identify cost-volume-profit relationships and solve CVP functions. & identify and analyze variances, flexible budges and management control.
CO3 - Identify and apply various types of costing and allocation of overhead for fixing price
CO4 - Identify and apply multi pool, multi driver costing method and activity-based costing.
CO5 - Evaluate the decision making for make/buy; product mix; expansion/contraction
CO6 -Identify and determine cost behavior & relevant information for decision making

TEXT/REFERENCE BOOKS

1. Cost Accounting: A Managerial Emphasis, Horngren, Datar and Rajan Prentice Hall
2. Management Accounting, Paresh Shah Oxford University Press.
3. Financial management by Prasana Chandra
4. Finance Sense by Prasana Chandra

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Question each of 5 marks Details 20 Marks
Part B/Question: 8 Questions each of 10 marks 100 Marks

20ME329T					Engineering Optimization					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	**25**	**50**	**25**	**--**	**--**	**100**

COURSE OBJECTIVES

- To know the basics of optimization problems.
- To understand various optimization algorithms.
- To formulate and solve interdisciplinary problem using optimization algorithm.

UNIT 1 INTRODUCTION **08 Hrs.**

Introduction to optimization: Optimization problem formulation- Design Variables, Constraints, objective function and variable bounds, optimization algorithms, applications and examples, different optimization methods available. Optimization criteria for single variable and multivariable optimization.

UNIT 2 CONVENTIONAL OPTIMIZATION: SINGLE VARIABLE **12 Hrs.**

Exhaustive search method, bound phase method, Fibonacci search method, Golden search method. Newton Raphson method, Bisection method, Root finding using optimization technique, Secant Method.

UNIT 3 CONVENTIONAL OPTIMIZATION: MULTI VARIABLE **12 Hrs.**

Unidirectional search method, Direct search method-Box's evolutionary, simplex search, Hooke Jeeves Pattern search; Gradient based method-Cauchy's method, Newton Method.

UNIT 4 SPECIALIZED METHODS AND NON CONVENTINAL OPTIMIZATION **12 Hrs.**

Integer programming, Geometric programming, Differences and similarities from traditional techniques, Genetic Algorithm, simulated annealing.

Max. 44 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1- To **Recall** the basics of mathematics.
CO2- To **Classify** the various optimization problems.
CO3- To **Apply** optimization techniques to **Solve** of single and multivariable problems
CO4- To **Distinguish** and understand the difference between conventional and non-conventional optimization techniques.
CO5- To **Evaluate** the performance of different optimization techniques.
CO6- To **develop** a matlab program for solving real life problem using non-conventional optimization algorithms.

TEXT/REFERENCE BOOKS

1. S. S. Rao, Engineering Optimization: Theory and Applications, New Age International, 3rd Edition, 2014.
2. K Deb, Optimization for Engineering Design: Algorithms & Examples, Prentice-Hall of India, 2nd Edition, 2012.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**
Part A-4 Questions: 10 Marks each 40 Marks
Part B-4 Questions: 15 Marks each 60 Marks

20ME330T					Design & Management of MSMEs					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To make students understand the Entrepreneurial process and also inspire them to be Entrepreneurs.
- To understand the setting up and management of MSMEs
- To know initiatives of Government and other institutions support for development of MSMEs.
- To understand New venture creation opportunities, its resources, for Enterprise Startup.

UNIT 1 Understanding Entrepreneurial Mindset **8 Hrs.**

The revolution impact of entrepreneurship- The evolution of entrepreneurship - Functions of Entrepreneurs – types of entrepreneurs - Approaches to entrepreneurship- Process approach- Role of entrepreneurship in economic development- Twenty first century trends in entrepreneurship. Entrepreneurial motivations- Motivational cycle – Entrepreneurial motivational behavior – Entrepreneurial competencies. Corporate Entrepreneurial Mindset,

UNIT 2 Launching Entrepreneurial Ventures & management **10 Hrs.**

Opportunities identification- Finding gaps in the market place – techniques for generating ideas- entrepreneurial Imagination and Creativity- the nature of the creativity process - Innovation and entrepreneurship. Methods to initiate Ventures- Creating new ventures- Acquiring an Established entrepreneurial venture- Franchising- advantage and disadvantages of Franchising. Introduction to management, Features of management, Nature of management, Principles of management, Fundamentals of planning, Types of business organizations

UNIT 3 FUNCTIONAL MANAGEMENT AREA IN ENTREPRENEURSHIP & Modern concept **15 Hrs.**

Core Concepts of Marketing, Marketing Mix (4p), Segmentation – Targeting – Positioning, Marketing Research, Marketing Information System, Marketing, Buying Behavior, Introduction to Operations Management, Types o f Operation Systems, Types of Layouts, Material Handling, Purchasing & Store System, Inventory Management, Location problem, Roles & Functions of Personnel Manager, Recruitment, Selection, Training, Industrial Dispute, Goal of Financial Management, Key Activities in Financial Management, Organization of Financial Management, Financial Institutions, Financial Instruments, Sources of Finance, Ratio Analysis, Capital Budgeting, Working capital Management, Introduction to ERP, e – CRM, SCM, RE –ZED Competitiveness program of MSMEs -SSIP, WTO, IPR, etc.

UNIT 4 Project Planning & sources of information for entrepreneurship **6 Hrs.**

Project report, Project appraisal, Setting up an industrial unit – procedure and formalities in setting up an industrial unit. State level Institutions, Central Level institutions and Other agencies SIDBI-NABARAD; CSIR …

Max. 39 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Students will be able to understand mindset of the entrepreneurs & identify options for launching
CO2 – Students will be able to understand & develop an idea on the legal framework and strategic perspectives
CO3- Students will be able to understand the Issues and opportunities in MSMEs & process of set up of MSMEs
CO4 – Students will be equipped with knowledge & understanding with regards to Management of MSMEs
CO5 – Students will know Institution and Government support for Start-up
CO6-students will appreciate the financial Issues of startups; its growth & Exit strategies

TEXT/REFERENCE BOOKS

1. D F Kuratko and T V Rao, Entrepreneurship- A South-Asian Perspective, Cengage Learning,
2. Bruce R. Barringer, Entrepreneurship Successfully launching new ventures, Pearson,
3. S.S.Khanka, Entrepreneurship Development, S. Chand Publications, .
4. Rajeev Roy, Entrepreneurship, 2e, Oxford publications, 2012.
5. Nandan .H, Fundamentals of Entrepreneurship, PHI, 2013
6. Web links of support organisation & various schemes will be shared

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4Q * 5 marks 20 Marks
Part B/Question: 8Q * 10 marks 80 Marks

20ME331T					Computational Engineering Laboratory					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	4	2	04	-	-	-	25	25	50

COURSE OBJECTIVES

- To introduce the software MATLAB and Engineering Equation Solver for numerical calculations and in particular familiarizing students with the basic commands through the command window and output through Graph window

MATLAB software

1. Introduction to MATLAB & MATLAB basics
2. Matrices, Basic Graphics, M-Files
3. Data Files, Directories, Text Strings, Arrays
4. Multidimensional Arrays, Cell Arrays, Structures
5. Programming with MATLAB
6. User defined functions and function files
7. Electric circuits, Control system
8. Different Toolbox of MATLAB
9. Engineering Mechanics with MATLAB
10. Numerical Methods with MATLAB
11. Numerical Integration with MATLAB
12. Solving Differential Equations with MATLAB
13. Introduction to MATLAB Simulink

Engineering Equation Solver

1. Introduction to EES
2. Menu Commands
3. Built in functions – thermal properties
4. Built in functions – physical properties
5. EES modules
6. EES functions
7. EES procedures
8. Advanced features of EES
9. Solution to algebraic equations
10. Blocking equation sets
11. Determination of minimum and maximum values
12. Example problem - I
13. Example problem - II

Max hours: 52

COURSE OUTCOMES

On completion of the course, student will be able to

CO-1: **Apply** programming operations to calculate solutions
CO-2: **Understand** the main features of the MATLAB program development environment and Engineeing Equation Solver
CO-3: **Develop** MATLAB and EES programs for simple and complex engineering problems
CO-4: **Create** professional-looking plots using MATLAB and EES commands
CO-5: **Interpret** the output graphical plots for the given governing equation
CO-6: **Apply** the MATLAB and EES programming to real time applications

TEXT/REFERENCE BOOKS

1. Higham, Desmond J., and Nicholas J. Higham. MATLAB guide. Society for Industrial and Applied Mathematics, 2016.
2. Klein, S. A., and F. L. Alvarado. "EES: Engineering Equation Solver, User manual." F-chart software (2019)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50	**Exam duration: 2 Hrs**
Part A: Lab work	25 marks
Part B: Viva Voce	25 Marks

20TP310					Industrial Training/ International Exposure Program					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	-	2	6 weeks summer break	--	--	--	--	100	100

COURSE OBJECTIVES

1. To provide students an exposure to the working environment of the industry
2. Understand the products being developed and/or services being offered by the industry
3. To cultivate the necessary technical report writing and oral presentation skills

COURSE OUTCOMES

On completion of the course, student will be able to:

CO1 – Understand the working of industry

CO2 – Utilize the technical skills required while working in the industry

CO3 – Apply the technical knowledge in real industrial scenario

CO4 – Evaluate the products being developed or services being offered by the industry

CO5 – Examine the process being employed for developing the products or services

CO6 – Acquire the necessary skills for technical report writing

Course Structure of B. Tech. in Mechanical Engineering

COURSE STRUCTURE FOR B.TECH. FOURTH YEAR (Mechanical Engineering)

SEMESTER VII (Subjects)				B.TECH. FOURTH YEAR (Mechanical Engineering)											
Sr. No.	Category Code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
				L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
									CE	MS	ES	CE	ES	
1	PCC	20ME402T	Optimization Techniques	3	0	0	3	3	25	25	50	-	-	100
2	PCC	20ME403T	Project Management	3	0	0	3	3	25	25	50	-	-	100
3	PCE	20ME4XXT	Professional Core Elective - IV	3	0	0	3	3	25	25	50	-	-	100
4	PCE	20ME4XXP	Professional Core Elective - IV Lab	0	0	2	1	2	-	-	-	25	25	50
5	PCE	20ME4XXT	Professional Core Elective - V	3	0	0	3	3	25	25	50	-	-	100
6	PCE	20ME4XXP	Professional Core Elective - VI	3	0	0	3	3	25	25	50	-	-	100
7	Project	20TP410	Seminar and Technical Writing	0	0	4	2	4	-	-	-	25	25	50
			Total	**15**	**0**	**6**	18	21						

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

Professional Core Elective – IV:

Course Code	Course Name		Course Code	Corse Name		Course Code	Course Name
20ME404T	Renewable energy application for Food, Energy and Water (FEW) security		20ME408T	Numerical Modelling and Simulation of Manufacturing processes		20ME412T	Welding for Metal Joining, Surfacing and Additive Manufacturing
20ME404P	Renewable energy application for Food, Energy and Water (FEW) security Lab		20ME408P	Numerical Modelling and Simulation of Manufacturing processes Lab		20ME412P	Welding for Metal Joining, Surfacing and Additive Manufacturing Lab
20ME405T	Alternate Fuels and Applications		20ME409T	Non-Destructive testing and failure analysis		20ME401T	Machine Design-II
20ME405P	Alternate Fuels and Applications Lab		20ME409P	Non-Destructive testing and failure analysis Lab		20ME401P	Machine Design -II Lab
20ME406T	Computational Fluid Dynamics and Heat Transfer		20ME410T	Computer Aided Manufacturing		20ME413T	Thermal analysis and CFD of manufacturing processes
20ME406P	Computational Fluid Dynamics and Heat Transfer lab		20ME410P	Computer Aided Manufacturing Lab		20ME413P	Thermal analysis and CFD of manufacturing processes Lab
20ME407T	Machine Learning Applications in Design and Manufacturing		20ME411T	Finite Element Analysis			
20ME407P	Machine Learning Applications in Design and Manufacturing Lab		20ME411P	Finite Element Analysis Lab			

Professional Core Elective – V & VI:

Course Code	Course Name		Course Code	Corse Name		Course Code	Course Name
20ME414T	Two Phase Flow and Heat Transfer		20ME420T	Phase Change Materials: Technologies and Application		20ME426T	Advanced Metaheuristics Optimization
20ME415T	Advanced Heat Transfer		20ME421T	Thermal System Design		20ME427T	Micro and Nano Manufacturing
20ME416T	Advances in Fluid Mechanics		20ME422T	Waste Heat Recovery		20ME428T	Advanced Materials and Characterizations
20ME417T	Cryogenics		20ME423T	Exergy Analysis of Thermal Systems		20ME429T	Lubrication
20ME418T	Heating, Ventilation and Air Conditioning		20ME424T	Solar Photovoltaic Fundamental: Technologies & Application		20ME430T	Elements of Mechatronics System Design
20ME419T	Hybrid Power Generation Systems		20ME425T	Machinery Fault Diagnosis and Signal Processing		20ME431T	Automobile Engineering
						20ME432T	Advance Manufacturing Process

20ME402T					Optimization Techniques					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

Course Objectives

- To impart the knowledge of unconstraint optimization techniques
- To learn constraints optimization techniques
- To understand classical and non-traditional optimization techniques

UNIT 1 **(10L)**

Introduction, need of optimization, objective function, constraints, design variables, feasible and infeasible solutions, classification of optimization problems, applications. Graphical Method: different cases, Feasible and infeasible solutions, redundant constraints, unbound solutions, unique solution.

UNIT 2 **(12L)**

Linear Programming, Problem formulation, simplex method, transportation and assignment problems, PERT and CPM

UNIT 3 **(12L)**

Unconstrained optimization techniques, elimination methods, interpolation methods, direct and indirect search methods.

UNIT 4 **(11L)**

Classical optimization techniques, single variable, multivariable optimization techniques, random search methods, methods of feasible directions

Total Lecture: 45 Hrs

Course Outcome:

On completion of the course, student will be able to

CO1: **Apply** basic concepts of mathematics to formulate an optimization problem.
CO2: **Use** LP techniques to obtain the solution of linear unconstraint problems.
CO3: **Apply** direct and indirect search techniques
CO4: **Understand** and apply classical optimization techniques
CO5: **Obtain** the solution of single and multivariable problems
CO6: **Apply** random search method to obtain feasible solution of the problems

Text/reference books

1. S.S.Rao, Engineering!Optimization, New Age International
2. K. Deb, Optimization for Engineering Design: Algorithms & Examples, Prentice-Hall of India
3. Ravindran, G. Reklaitis, K.M. Ragsdell, Engineering Optimization: Methods and Applications, Wiley

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME403T					Project Management					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the importance of Project Management in the context of Industry 4.0
- To create project plan and schedule for monitoring project deliverables.
- To deliver successful projects that support organizations strategic goals.

UNIT 1 Introduction to Project Management(PM): **11 Hrs.**

Importance of PM in the context of Industry 4.0, What is Project Management, Projects & Operations, The Project Life Cycle, Project Stakeholders, Project Management Process, Groups, Project Management Knowledge Areas, Project Initiation: The Project Charter, Stakeholder register, The Project Scope Document, Work Breakdown Structures, Project Contracts – Scope, Delivery, Costs and Risks.

UNIT 2 Project Planning and Scheduling **11 Hrs.**

Project Network Representations, Activity Parameter Estimation – Time, Cost and Resources, Project Time Schedule, Gantt Charts, CPM and PERT, Activity and Project Crashing, Resources Scheduling. Developing project management plan for sample project.

UNIT 3 Project Execution Management: **9 Hrs.**

Quality Specifications, Quality Control Tools, Resources. Procurement and Allocation, Systems and Processes, Communications and Documentation, Managing Teams, Resources Demobilization, Project Simulation and Risk Assessment, Use of IT tools. Agile Approaches for Successfully Managing and Executing Projects in the Fourth Industrial Revolution, Case study on Project Execution.

UNIT 4 Project Monitoring & Control Process and Project Closure **9 Hrs.**

Monitoring Process (on a regular basis)-Monitoring and controlling activities, Key Results from monitoring process; Techniques to evaluate project performance- Earned Value Analysis, The Critical Ratio, Review Meetings; Project Crashing and Time-Cost Trade-Off ,Performance Evaluation – Scope, Time and Cost, Performance of Teams, Lessons Learnt, Project Closure Report. Integrated Examples/Cases.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Define** the fundamental processes related to project management.
CO2 - **Understand** and **Apply** the Project management principles on project planning and scheduling concepts.
CO3 – Define and understand the concept of quality in terms of industrial perspective.
CO4 – **Apply** and **Analyze** the project execution processes for case studies
CO5 - **Apply** Project management tools for effective project monitoring and control processes.
CO6 – **Understand** the necessity of project closure and apply the same on case studies.

TEXT/REFERENCE BOOKS

1. PMBOK® Guide, 6thEdition
2. Mantel Jr., Samuel J., Jack R. Meredith, Scott M. Shafer, Margaret M. Sutton with M. R.
3. Gopalan (2006) ,Project Management Core Text Book, First Indian Edition, Wiley, New Delhi.
4. Maylor, Harvey Project Management (2003), 3/e, Pearson, New Delhi.
5. Pinto, Jeffrey K. Project Management: Achieving Competitive Advantage and MS Project (2009), 1/e, Pearson, New Delhi.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Part A/Question: 8 Questions from all units, each carrying 10 marks	80 Marks
Part B/Question: 4 Questions from all units, each carrying 5 marks	20 Marks

20ME404T					Renewable energy application for Food, Energy and Water (FEW) security					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/ Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop the human recourse in Renewable Energy sector which is the need of the hour.
- To Explain the climate change and effects of non-conventional energy on environment
- To create several self-employment opportunities in renewable energy and energy efficiency sectors for modestly- trained and self-trained human resources exist in all geographic locations of the country.

UNIT 1 FEW concepts and principles (10)

FEW concepts and principles: Case studies of critical WEF issues within and between nations, climate, economic, optimization, and integrated assessment models, creative solutions to current and emerging policy dilemmas

UNIT 2 Food and Water security- renewable energy applications and way forward (12)

Agricultural inputs, pumping and transfers, shipping, food utilization, Irrigation, groundwater resources, water quality and water value, High recovery desalination, Water supply and treatment, urban/rural competition, urban agriculture, sustainability Food security, projections and challenges. Carbon-free energy options and applied designs based on Renewable Energy: Solar, Wind & Biomass for water treatment and food preservation

UNIT 3 Renewable Energy System (13)

Hydropower, thermoelectric cooling, renewables, conventional and unconventional fossil fuel extraction, Carbon based energy system, Carbon cycle, greenhouse gases and global warming; Climate change – causes and consequences, Carbon capture, storage & Utilization. Pricing water and energy, subsidies, privatization, externalities, investment, public-private partnership

UNIT 4 Other Non-conventional Energy Sources: (10)

Geothermal; Fuel cell & Hydrogen fuels, Life cycle Assessment of Carbon- based and Carbon-free energy options. Impact on human life through Environmental Protection, Pollution Control and Climate Change: clean air, water and land.

Max : 45 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1- Develop the skills required in renewable energy and energy management fields.
CO2- Demonstrate an overview of energy resources and energy consumption
CO3- Explore proficiencies and skills for becoming successful scientist, technicians in renewable energy sector
CO4- Analyze Synergy between energy and environment with related environment issues.
CO5- Apply awareness of environmental protection and application of renewable energy.
CO6– Learn different techniques in renewable energy sector and its environmental impact

TEXT/REFERENCE BOOKS

1. S.P. Sukhatme, Solar Energy – Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi,
2. J. A. Duffie and W.A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
3. D. D. Hall and R. P. Grover, Biomass Renewable Energy, John Wiley, New York, 1987.
4. Rao S., Parulekar B.B., Energy Technology-Non conventional, Renewable and Conventional, Khanna Publishers, Delhi
5. Glynn Henry J., Gary W. Heinke, Environmental Science and Engineering, Pearson Education, Inc, 2004.
6. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition, Prentice Hall, 2003.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME404P					Renewable energy application for Food, Energy and Water (FEW) security Lab		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester LE/Viva	
0	0	2	1	2	25	25	50

Course objectives:

- **To analyse, differentiate** and **evaluate** different uses through various renewable energy sources
- **To evaluate** and **apply** different designs for low cost **applications**
- **To demonstrate** applied mechanisms through which objectives are achieved using alternate energy sources

List of Experiments:

1. Modelling and design of low cost high recovery water treatment system
2. Design optimization of thermal energy based high recovery Batch Reverse Osmosis system using steam Rankin cycle
3. Performance enhancement of solar dryer system
4. Exergy analysis of parabolic dish collector
5. Design and performance analysis of LiBr-H_2O VAR system for cooling applications
6. Study of integrated Reverse Osmosis- Forward Osmosis water treatment system
7. Solar PV based Electro coagulation and Electro dialysis experiment
8. Organic Rankine cycle based cascade Reverse Osmosis system for reduced SEC water treatment operation

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Evaluate and discuss experimental uncertainty.
CO2: Identify the Renewable energy application for Food, Energy and Water (FEW) security
CO3: Evaluate the performance of renewable energy operated systems.
CO4:Construct chart and graphs.
CO5: Create publication-quality lab reports.
CO6: Enhance the presentation and team work skills.

TEXT/REFERENCE BOOKS

1. S.P. Sukhatme, Solar Energy – Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi,
2. J. A. Duffie and W.A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991
3. D. D. Hall and R. P. Grover, Biomass Renewable Energy, John Wiley, New York, 1987.
4. Rao S., Parulekar B.B., Energy Technology-Non conventional, Renewable and Conventional, Khanna Publishers, Delhi
5. Glynn Henry J., Gary W. Heinke, Environmental Science and Engineering, Pearson Education, Inc, 2004.
6. Gilbert M. Masters, Introduction to Environmental Engineering and Science, 2nd Edition, Prentice Hall, 2003.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks	**Exam Duration: 2 hrs**
Quiz/Experiment	10 Marks
Viva	15 Marks

20ME405T					Alternate Fuels and Applications					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Introduction to classification of various alternative fuels and their applications.
- Understand biofuel production methods.
- Update the knowledge of biofuels regarding engine performance and testing results.
- Aware of fuel properties and available standards.

UNIT 1 Bio-Energy Systems **12 Hrs.**

Biomass Gasifiers: Principle, Design of Bio mass Gasifiers, updraft gasifier, downdraft gasifier, zero carbon biomass gasification plants, applications for cooking, electricity generation, Gasifier Engines, Operation of spark ignition and compression ignition engine with wood gas, Biomass integrated gasification/combined cycles systems. Biogas Systems: Technology of Bio-gas production, Biogas Plants, Digester types, Digester design, Chemical kinetics of bio-methanation process, Dung, Vegetable Waste and Night Soil and Municipal Waste based Bio -gas plants, Lighting, Electricity generation, Bio gas Bottling Plant Technology, Application of Bio gas slurry in agriculture, Design of Biogas for cold climates

UNIT 2 Biodiesel **12 Hrs.**

Feedstock: non-edible vegetable oils and waste cooking oil; raw oil characterization; transesterification reaction and process parameters; Conventional and PI techniques for biodiesel production; blending, physicochemical properties and comparison with fuel standards; Application to CI engines: Performance and emission testing; introduction to aviation fuels

UNIT 3 Gaseous fuels **10 Hrs.**

Biogas: Constituents, properties, automotive applications Hydrogen: Physical and chemical properties; production techniques; storage systems; Application: IC engines and fuel cell. LPG and CNG: properties, fuel metering system, combustion characteristics, Industrial applications, performance and emission testing Alternate designs for Gasifier Engines for bio gas, hydrogen, LPG and CNG for improved efficiency

UNIT 4 Other Alternate Fuels and Technologies **06 Hrs.**

Other Alternative fuels: Di-Methyl Ether (DME), Pyrolysis gas/oil, Synthetic gas/oil from plastic, rubber, coal, etc., Eco Friendly Plastic fuels (EPF), Energy from Algae: Algae Cultivation, Photo-bioreactors, Harvesting, Sewage and Waste water growth conditions, algae biomass, algal meal/cake, Integration of CO2 emitting industries for growth of Algae, Other applications of Algae: food, pigment etc.

Max 40 hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Define the fundamental terminologies used in alternative fuels
CO2 - Explain the policies and feedstock available for alternative fuels
CO3 - Analyse and compare the production methods of fuels
CO4 - Identify the fuel performance and emission testing results of IC engine testing
CO5 - Compile the information regarding gaseous fuels
CO6 - Explore the sustainable option for other alternative fuels

TEXT/REFERENCE BOOKS

1. Alternate Fuels by Dr. S. Thipse, Jaico Publications.
2. Automotive Emission Control" by Crouse, AND Anglin – McGraw Hill
3. Alternative Fuels Guidebook" by Bechtold R.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Unit 1/Question: Question 1 with subsections(with internal choice)	25 Marks
Unit 2/Question: Question 2 with subsections(with internal choice)	25 Marks
Unit 3/Question: Question 3 with subsections(with internal choice)	30 Marks
Unit 4/Question: Question 4with subsections(with internal choice)	20 Marks

20ME405P					Alternative fuels and applications Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- To analyse, differentiate and evaluate the production process of renewable fuels using Process Intensification Techniques.
- To evaluate the feed stock characterization and fuel properties as per the standards.
- To conduct performance and emission testing using internal combustion engines.

List of Experiments:

1. To perform experiment to determine fuel characterization of non-edible oil.
2. To conduct experiments for biodiesel production from WCO/non-edible oil using PI techniques US, MW, Hybrid, PSWR).
3. Experimental determination of various physic-chemical properties of fuel produced in the laboratory and comparison with the standards.
4. To perform engine performance and emission testing.
5. To conduct experiment on pre-treatment of feedstock.

(Each of the above experiment require minimum two terms (4 hrs)

Max. 26 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Understand** the non-edible feedstock for renewable liquid fuel production
CO2 - **Evaluate** and compare the PI techniques used for bio-fuel production process.
CO3 - **Understand** and **analyse** physio-chemical properties of liquid fuels.
CO4 - **Understand** and **analyse** pre-treatment process to upgrade feedstock
CO5 - **Examine** the performance and emission data of IC engines.
CO6 - **Compile** and interpret the experimental data and compare with the standards

TEXT/REFERENCE BOOKS

1. Laboratory manual
2. Research paper related to experimental studies.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks	**Exam Duration: 2 hrs**
Quiz/Experiment	10 Marks
Viva	15 Marks

20ME406T					Computational Fluid Dynamics and Heat Transfer					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To numerically **solve** governing partial differential equations for transport processes.
- To **analyze** different mathematical models and computational methods for transport processes.
- To **study**, and **apply** discretization methods & schemes and analyze its effect on the accuracy of numerical solution and computational time.
- To **demonstrate** the ability to use modern CFD software tools.

UNIT 1 INTRODUCTION **8 Hrs.**

Introduction to Computational Fluid Dynamics. Classification of various types of equations parabolic, elliptic, hyperbolic and mixed type; Boundary and initial conditions; Overview of numerical methods.

UNIT 2 FINITE DIFFERENCE METHOD **10 Hrs.**

Finite Difference Method - explicit, implicit, stability requirement, boundary conditions. Errors and analysis of stability, Von-Neumann stability analysis. Methods of Solution: Solution of finite difference equations Solution procedures: direct and iterative methods.

UNIT 3 FINITE VOLUME METHOD **12Hrs.**

Introduction to Finite volume method for general transport convection/diffusion equations. Solution algorithms for pressure-velocity coupling – SIMPLE algorithm. Staggered/Collocated grid concepts.

UNIT 4 APPLICATION OF CFD **12 Hrs.**

Application of modern CFD-toolbox/software Open FOAM/Dolfyn/ANSYS/FLUENT/STAR-CCM+/MATLAB: analysis for fluid and heat transfer problems. Heat transfer analysis in a double pipe heat exchanger. Internal fluid flow and heat transfer study in a centrifugal pump. Heat conduction study in 2D flat plate. Simulation of a generic convection-diffusion transport equation with forced/natural convention over flat plat/in pipe. External flow analysis over NACA airfoil and Vortex shedding over cylinder.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Solve** the governing partial differential equations of fluid flow and heat transfer problems.
CO2 - **Construct** and solve the different mathematical models and computational methods for fluid flows.
CO3 - **Apply** the discretization methods to solve fluid flow and heat transfer problems.
CO4 - **Choose** and justify the CFD schemes for the respective fluid flow/transport phenomena problem.
CO5 - **Perform** verification and validation of numerical model.
CO6 - **Demonstrate** the ability to use modern CFD software tools.

TEXT/REFERENCE BOOKS

1. Patankar, Suhas. Numerical heat transfer and fluid flow. Taylor & Francis, 2018.
2. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.
3. Computational Fluid Dynamics (Vol. 1) 4th Edition by Klaus A. Hoffmann & Steve T. Chiang , Engineering Education System 2000.
4. Computational Fluid Dynamics, J. D. Anderson Jr., McGraw-Hill International Edition, 1995.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Four questions form each unit 40 Marks

Part B/Question: Four questions form each unit 60 Marks

20ME406P					Computational Fluid Dynamics and Heat Transfer LAB		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					LW	LE/Viva	
0	0	2	1	2	25	25	50

COURSE OBJECTIVES

- To utilize the various computational tools to understand the fluid flow.
- To employ the various computational tools to comprehend heat transfer problems.
- To apply the knowledge of several numerical schemes to solve the governing equations of physical systems.
- To understand and simulate several flow situations with forced/natural convection with Internal and external flows.
- To validate the simulation results with that of existing experimental/analytical results.

List of Experiments

Experiment 1: External flow analysis over NACA 0012 airfoil for different angle of attacks.
Experiment 2: Fluid flow and heat transfer analysis in a double pipe heat exchanger.
Experiment 3: Internal fluid flow and heat transfer study in a centrifugal pump.
Experiment 4: Analysis of Karman-Vortex over a cylinder (Vortex shedding).
Experiment 5: Couette flow analysis for both explicit and implicit formulation (Parabolic equation).
Experiment 6: Heat conduction in 2D flat plate with explicit and implicit formulation (Elliptic equation).
Experiment 7: 1D wave propagation in a still lake (Hyperbolic equation).
Experiment 8: 2D simulation of Rayleigh–Taylor instability (VOF method).
Experiment 9: Lid driven cavity flow analysis utilizing vorticity-streamfunction framework.
Experiment 10: Study of different turbulent models to analyse the flow in a pipe for various Reynolds number.
Experiment 11: Simulation of a generic convection-diffusion transport equation with forced/natural convention over flat plat/in pipe.

Note - (Student can use any modern CFD-toolbox/software OpenFOAM/Dolfyn/ANSYS/FLUENT/STAR-CCM+/MATLAB to perform above Lab experiments based on the recommendation of Faculty.)

COURSE OUTCOMES

On completion of the course, student will be able to
CO1: **Understand** the computational software tools to analyse the fluid flow problems.
CO2: **Utilize** various computational tools to comprehend heat transfer problems.
CO4: **Classify** and evaluate the physics of problems and apply the appropriate discretization schemes.
CO5: **Analyse** and understand the results through post-processing for a given problem.
CO6: **Compare** the simulation results with that of existing experimental/analytical results.

TEXT/REFERENCE BOOKS

1. Patankar, Suhas. Numerical heat transfer and fluid flow. Taylor & Francis, 2018.
2. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 2 Hrs**

Part A: Lab Manual 25 Marks

Part B: Viva 25 Marks

20ME407T					Machine Learning Applications in Design and Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To learn the advantages and architecture of machine learning algorithms.
- To design and formulate the algorithms from scratch.
- To select suitable algorithm for practical implementations.
- To systematically analyze the algorithms for design and manufacturing applications.

UNIT 1 Introduction **11 Hrs.**

History of Artificial Intelligence, Development, Architecture, Hardware and Software, Advantages and Disadvantages, Data Mining, Data Analysis, Machine Learning Case Study

UNIT 2 Machine Learning Techniques **12 Hrs.**

Introduction, Supervised, Unsupervised learning and semi supervised learning, advantages and disadvantages, regression analysis, forecasting techniques, cluster analysis, feature vector and its application for classification and regression analysis.

UNIT 3 Classification and Regression Analysis of Mechanical components **11 Hrs.**

Linear vs Non Linear Classifier, Linear regression, Logistic regression, Support vector Machine , Case study for rotating components such as bearing, gears, pumps etc.

UNIT 4 Classification and Regression Analysis in Manufacturing **11 Hrs.**

Historic development of Artificial Intelligence and Machine learning for manufacturing applications, Artificial neural network, Architecture, types of Artificial neural network ,Trees for classification and regression. Case study for tool wear rate classification and prediction, Texture analysis of machined components, future directions.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** the basics of machine learning and artificial intelligence.
CO2: **Analyze** and **Prepare** suitable architecture of machine learning framework.
CO3: **Identify** the suitable algorithm for implementations.
CO4: **Comprehend** various types of machine learning algorithms.
CO5: **Formulate** and **Organize** appropriate algorithm for rotary components.
CO6: **Design** and implement applications of classification and regression in manufacturing domain.

TEXT/REFERENCE BOOKS

1. D. Forsyth, Applied Machine Learning, Springer, first edition (2019)
2. E. Alpaydin, Introduction to Machine Learning, Pearson third edition (2015)
3. S.O. Hykin, Neural Networks and Learning Machines, Pearson ,third edition (2016)
4. C. Bishop, Pattern Recognition and Machine Learning, Springer, first edition (2006)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A : 2 Questions each carrying 5 Marks	10 Marks
Part B : 3 Questions each carrying 10 Marks	30 Marks
Part C : 4 Questions each carrying 15 Marks	60 Marks

20ME407P					Machine Learning Applications in Design and Manufacturing Lab		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Lab Work	Lab Exam/Viva	Total Marks
--	--	2	1	2	25	25	100

COURSE OBJECTIVES

- To introduce implementation of machine learning techniques.
- To develop skills for implementation of design and manufacturing applications.
- To identify/select appropriate algorithm for practical implementations.

List of Practical

1. Fault Defect Identification of Ball Bearing using Naive Bayes.
2. Fault Defect Identification of Gears using Artificial Neural Network.
3. Classification of Machined Images using Support Vector Machine.
4. Prediction of Tool Wear Rate using Linear Regression.
5. Prediction of Material Removal Rate using Isotonic Regression.
6. Prediction of Surface Roughness using Logistic Regression.
7. Development and Design of Regression Equations for Manufacturing Applications.
8. Selection of Suitable Parameters of Machine Learning Classification Algorithms.
9. Selection of Suitable Parameters of Machine Learning Regression Algorithms.
10. Implementation of Unsupervised Algorithms for Classification.

COURSE OUTCOMES

On completion of the course, student will be able to
CO1: **Recall** and identify various machine learning techniques.
CO2: **Formulate** algorithms for classification.
CO3: **Formulate** algorithms for regression
CO4: **Compare** and analyze the performance metrics for design applications.
CO5: **Compare** and analyze the performance metrics for manufacturing applications.
CO6: **Identify** and comprehend suitable parameters for analyzing the performance of algorithms.

REFERENCE MATERIALS

1. Lab Manual and Course Material.
2. E. Alpaydin, Introduction to Machine Learning, Pearson, third edition (2015)
3. D. Forsyth, Applied Machine Learning, Springer, first edition (2019)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs**
Part A : Lab examination – Experiments/FEA 25 Marks
Part B : Viva 25 Marks

20ME408T					Numerical Modelling and Simulation of Manufacturing processes					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide fundamental knowledge of advanced manufacturing processes and heat transfer and fluid flow.
- To derive governing equations for mass, momentum and energy with classification of differential equations
- To provide knowledge of different numerical methods to solve governing equations.
- To explain modelling steps for modelling software to develop a model for manufacturing process.

UNIT 1 **10 Hrs.**

Fundamentals of Manufacturing Processes: Basics of manufacturing processes - casting, forming, welding, machining- need of optimization of process parameters, Need and role of numerical modelling. Basics of heat transfer and fluid mechanics required for modelling.

UNIT 2 **10 Hrs.**

Fundamental of Numerical Modelling: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description. **Mathematical Representation of physical problems:** Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions.

UNIT 3 **14 Hrs.**

Numerical Methods: Classification and overview of Numerical Methods, Finite Difference method: Taylor series expansion. Finite Volume Method: Different types of finite volume grids; interpolation methods; central, upwind and hybrid formulations. Finite Element Method - Rules for forming interpolation functions – Shape Functions, Application to fluid flow and heat transfer problems.

UNIT 4 **8 Hrs.**

Introduction and Application of numerical modelling software: Geometric modelling, mesh generation, boundary and initial conditions, computational approach, analysis. **Case study:** Numerical modelling of various manufacturing processes.

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Understand fundamental knowledge of advanced manufacturing processes and requirement of optimizing manufacturing processes using numerical modelling techniques.
CO2: Apply the fundamentals of heat transfer and fluid mechanics in numerical modelling
CO3: Derive and apply the conservation equations to represent the physical system in mathematical form
C04: Derive different types of differential equations to represent physical problems.
CO5: Understanding various numerical methods to solve different governing equations.
CO6: Apply numerical analysis to develop model for manufacturing process.

TEXT/REFERENCE BOOKS

1. S Kalpakjian, Manufacturing processes for engineering materials, 3rd Edition, Addison Wesley Longman, 1997.
2. V. K. Jain, Advanced Machining Processes, Allied Publishers Mumbai J Schey, Introduction to Manufacturing processes, 3rd Edition, Tata McGraw Hill, 2000.
3. Henk Kaarle Versteeg, Weeratunge Malalasekera: An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Ltd., 2007
4. Computational Fluid Dynamics, John D. Anderson Jr., McGraw Hill Book Company.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions from each unit, each carrying 10 marks 40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks 60 Marks

20ME408P					Numerical Modelling and Simulation of Manufacturing processes Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- To understand fundamentals of numerical modelling to solve physical system.
- To provide knowledge of different types of meshes.
- To understand role of different boundary conditions to solve the governing equations.
- To utilize commercial software to perform modelling of different heat transfer, fluid flow and manufacturing processes.

List of Experiments:

1. Development of 2D and 3D CAD Geometry of physical system using commercial based software
2. To discretize computational domain and generating different types of mesh using commercial based software
3. Apply different types of boundary conditions for various physical systems
4. Development of a numerical model for heat transfer system
5. Development of a numerical model for fluid flow system
6. Development of numerical model for welding process.
7. Development of numerical model for advanced manufacturing processes.

COURSE OUTCOMES

CO1: Apply fundamentals of modelling and simulation in solving physical system.
CO2: Develop different types of mesh for modelling
CO3: Demonstrate different boundary conditions to solve the governing equations
CO4: Analyse numerical modelling for heat transfer systems
CO5: Construct modelling concepts for fluid flow systems
CO6: Develop numerical model for different manufacturing process.

TEXT/REFERENCE BOOKS

1. Henk Kaarle Versteeg, Weeratunge Malalasekera: An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Pearson Education Ltd., 2007
2. Serope Kalpakjian, Steven R Schmid, Manufacturing Process for Engineering Materials, 4th Edition, Pearson Education, 2003.

END SEMESTER LAB EXAMINATION

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz/Experiment	10 Marks
Viva-Voce/mini project	15 Marks

20ME409T					Non-Destructive testing and failure analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

1. To introduce and familiarize the different Non-destructive testing techniques and its importance in manufacturing.
2. To understand basic working principle and its allied aspects for different widely used NDT techniques.
3. To enable the students for doing Failure analysis of a component and make them aware about different tools used.
4. To make student aware about the latest advancement in the codes and standards followed in NDT as well as advanced tools pertaining to Industry 4.0 in NDT.

UNIT 1 **11 Hrs.**

Failure Analysis – I: Failure analysis – methodology; approaches, tools and techniques of failure analysis; modes of failure; failure data retrieval; procedural steps for Investigation of a failure for failure analysis. **Failure Analysis – II:** Improvements (design, material) derived from failure analysis; two case studies; application of fracture mechanics concepts to design for safety. **Techniques for Failure identification:** Optical Microscopy, X-RAY Diffraction, Electron microscopy

UNIT 2 **11 Hrs.**

Manufacturing DEFECTS : Origin - types - process induced defects, - significance – remedial Measures, e.g. Micro cracks, Hot cracking - cold cracking -lamellar tearing - reheat cracking. **Introduction to NDT:** Introduction to Non-Destructive Testing (NDT), its relevance, importance and key features. Classification of NDT techniques and its various applications. Selection of NDT techniques and their importance in the field of reliability analysis as well as remaining life assessment (RLA). Brief introduction to 16 methods of NDT and brief introduction to 6 widely used NDT techniques. **Visual examination:** Fundamentals of defects, root causes of defects, tools and techniques for visual observation. Acceptance standards and application.

UNIT 3 **13 Hrs.**

LPT, MPT: Liquid penetrant testing – procedure; penetrant testing materials, penetrant testing method – sensitivity; application and limitations; magnetic particle testing; definition and principle; magnetizing technique, procedure, equipment sensitivity and limitation; Application & Acceptance Standards **RADIOGRAPHY:** Basic principle, electromagnetic radiation in film, radiographic imaging, inspection techniques, applications, limitations, real time radiography, safety in Industrial radiography. Application & Acceptance Standards. **Ultrasonic Techniques:** Ultrasonic transducers, inspection methods, technique for normal beam inspection, flaw characterization technique, ultrasonic flaw detection equipment modes of display, immersion testing, advantage, limitations; Application & Acceptance Standards

UNIT 4 **10 Hrs.**

Eddy current testing: Principle, instrument techniques, sensitivity application, limitation; ultrasonic testing – basic properties of sound beam, Application & Acceptance Standards **Acoustic emission testing:** Principles of AET and techniques, its application, Acceptance standards. **Codes & Standards:** Introduction to codes and standards, necessity, importance and various codes worldwide. Introduction to ASME codes and its various sub-sections. Requirements of ASME Sec-V code and its interpretation. **Introduction to various codes and standards across the world such as ISO, ASTM, ASNT, etc.** Use of automation, AI and Industry 4.0 in testing techniques and its case studies

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** the basic concept of Failure analysis and apply it for remaining life assessment.
CO2: **Evaluate** the various defects in manufacturing, basis of NDT and principles of visual testing.
CO3: **Explain** the various methods of NDT such as LPT, MPT and its relevance in manufacturing.
CO4: **Demonstrate** the NDT method of RT and UT and its application on real life manufacturing scenario.
CO5: **Evaluate** the advanced NDT technique such as AET and ECT for manufacturing applications.
CO6: **Compose** the different codes and standards of NDT and use of industry 4.0 tools for Non-destructive testing.

TEXT/REFERENCE BOOKS

1. Baldev Raj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive, 2002
2. Testing', Narosa Publishing, 1997.
3. Das A.K., 'Metallurgy of Failure Analysis', TMH, 1992.
4. Hull., 'Non-Destructive Testing', ELBS Edition, 1991
5. Halmshaw R., - 'Non-Destructive Testing', Edward Arnold, 1990

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 4 Questions from each unit, each carrying 10 marks	40 Marks
Part B/Question: 4 Questions from each unit each carrying 15 marks	60 Marks

20ME409P					Non-Destructive testing and failure analysis Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

1. To introduce and familiarize the different Non-destructive testing techniques and its importance in manufacturing.
2. To understand basic working principle and its allied aspects for different widely used NDT techniques.
3. To enable the students for doing Failure analysis of a component and make them aware about different tools used.
4. To make student aware about the latest advancement in the codes and standards followed in NDT as well as advanced tools pertaining to Industry 4.0 in NDT.

List of experiments

1. Demonstration of different techniques of Non-destructive testing.
2. To detect the defects in a component using liquid penetrant testing method.
3. To detect the defects in a component using Magnetic particle testing method.
4. To detect the defects in a component using Ultrasonic testing method.
5. To interpret the defects in a component from a radiography film.
6. To detect the defects in the inner part of the pipe using Borescope.
7. Demonstration of the phased array ultrasonic testing method.
8. Demonstration of the time-of-flight deflection ultrasonic testing method.
9. Demonstration of different techniques of Failure analysis such as Macro, micro, sem etc.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Understand the working principles and operations of various NDT instruments.
CO2 - Analyse the effect of different parameters on the measurements and methodologies.
CO3 - Demonstrate the significance of different instruments for different measurements.
CO4 - Judge the uses of appropriate techniques for different measurement applications in practical life.
CO5 - Appraise the limitations of each measurement technique and methodologies followed.
CO6 – Explain the qualitative significance of the quantitative results obtained.

TEXT/REFERENCE BOOKS

1. Baldev Raj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive, 2002
2. Testing', Narosa Publishing, 1997.
3. Das A.K., 'Metallurgy of Failure Analysis', TMH, 1992.
4. Hull., 'Non-Destructive Testing', ELBS Edition, 1991
5. Halmshaw R., - 'Non-Destructive Testing', Edward Arnold, 1989

END SEMESTER LAB EXAMINATION

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz/Experiment	10 Marks
Viva-Voce/mini project	15 Marks

20ME410T					Computer Aided Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand detail of CNC machines
- To implement concept of manual part programming
- To provide fundamentals of flexible manufacturing system and robotics
- To understand group technology and cellular manufacturing

UNIT 1 Introduction to CNC machines **10 Hrs.**

Introduction to CAM, Nature & type of manufacturing system, NC, CNC and DNC systems, Elements of CNC machine - Slide ways, motion transmission elements, Automatic tool changers and multiple pallet systems, feedback devices - encoders and transducers, sensors, actuators,Spindle drives and axes drives, Tooling for CNC machines-Tool preset and qualified tools, work and tool holding devices

UNIT 2 CNC part programming **14 Hrs.**

Axis identification and coordinate systems, Programming formats. Manual part programming for a turning center- Do loop, Sub routines and canned CNC lathe cycles. Manual part programming for CNC milling center - Do loop, Subroutines and Canned milling cycles. CNC part programming using APT language.

UNIT 3 Flexible Manufacturing System **14 Hrs.**

Introduction of FMS, Types of FMS, Manufacturing Cells, JIT & GT applied to FMS, FMC, Tool Management, industrial robotics and material Handling, AS/RS, AGVS , RGV, Flexible Fixturing, Flexible Assembly Systems, FMS scheduling, sequencing, FMS lay out and essentials

UNIT 4 Group Technology and Cellular Manufacturing **14 Hrs.**

Introduction, part families, part classification and coding, machining cells, production flow analysis, Cellular Manufacturing, **Computer Aided Production management-** Introduction, PPC fundamentals, Problems with traditional PPC, use of computer in PPC such as CAPP, MRPI, MRPII, CAGC etc.

Max. 52 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Understand** CNC machine structures and system drives
CO2: **Analyze** basics and advancement in NC and CNC for automatic manufacturing
CO3: **Create** manual and APT part programs for complex profiles for Lath and milling machine
CO4: **Understand** role of FMS, JIT, and Robotics in material movement in manufacturing
CO5: **Apply** the concepts of group technology and cellular manufacturing in automation
CO6: **Understand** computer aided production management in industries

TEXT/REFERENCE BOOKS

1. Chang, Tien-Chien, and Richard A. Wysk. Computer-aided manufacturing. Prentice Hall PTR, 1997.
2. Groover, Mikell P. Automation, production systems, and computer-integrated manufacturing. Pearson Education India, 2016. CNC Programming - Principles and Applications, Mike Mattson, Cengage Publication.
3. Sinha, Sanjay Kumar. CNC programming using FANUC custom macro B. McGraw Hill Professional, 2010.
4. Luggen, William W. Flexible manufacturing cells and systems. Prentice Hall, 1991.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME410P					Computer Aided Manufacturing Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	-	-	-	25	25	50

COURSE OBJECTIVES

- 1. To understand the different CNC programming, their compatibility and limitations.
- 2. To apply the fundamentals and principles of CNC programming for Lath Machine.
- 3. To apply the fundamentals and principles of CNC programming for Milling Machine.

List of Experiments:

1. Demonstration of CNC Milling machine with user interface and calculating the Co - ordinates of given geometry in absolute end increment mode for cutter path.
2. Write the CNC programming for a given geometry using Mirror and Subroutine.
3. Write the CNC programming for a given geometry for drilling cycles.
4. Write the CNC programming for a given geometry using Tool Radius Compensation and Repeat loop for Peck drilling cycles.
5. Introduction and programming of all canned cycle of milling machine.
6. Perform the Various turning operation on CNC turning/lathe.
7. Perform the Various machining operation on CNC milling/machining centre.
8. Perform the various drilling operation on CNC milling/machining centre.
9. Demonstration of As /Rs and AVG operation.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Develop manual part programs for 2D-complex profiles for Fanuc and Siemens controller using CNC Simulator and Sinutrain Software

CO2: Develop G and M codes for turning and milling components

CO3: Build and verify CNC code using Virtual CNC software

CO4: Utilize automated tool paths for a given engineering component

CO5: Demonstrate machine complex profiles on CNC machine using auto generated CNC code

CO6: Understand the working of material handling systems

TEXT/REFERENCE BOOKS

1. CNC Programming - Principles and Applications, Mike Mattson, Cengage Publication.2009
2. CNC programming – Dr.S.K.Sinha – Golgotia publications. 2002

END SEMESTER LAB EXAMINATION

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz/Experiment	10 Marks
Viva-Voce	15 Marks

20ME411T					Finite Element Analysis					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	50	100	25	--	--	100

COURSE OBJECTIVES

- To learn the theory and characteristics of finite element methods.
- To formulate the stiffness matrix for linear, quadratic and higher order elements for 1D, 2D and 3D cases.
- To learn and solve problems of beam, truss, frame, grid, plates, dynamic, thermal and fluid using variational and displacement methods.

UNIT 1 Introduction **12 Hrs.**

Introduction to Finite Element Method, Basic Concepts and Steps in FEM formulations, Discretization, General Applications of the Method, Comparison with other numerical methods, Integral formulations and Variation methods: Need of weighted Integral forms, Differential equations and Functional forms, Galerkin Methods, Point Collocation methods, Weak Formulations, Rayligh-Ritz Methods, Concept of Interpolation

UNIT 2 Finite Element Analysis of One Dimensional problems **10 Hrs.**

Linear, Quadratic and Higher order Elements, Beam Elements, Truss, and Grid Elements

UNIT 3 Finite Element Analysis of two and three Dimensional problems **15 Hrs.**

Triangular, Quadrilateral and rectangular element, Natural Coordinates and Coordinates transformations, Connectivity of Elements, Introduction to 3D problems and its theoretical formulation

UNIT 4 Applications of Finite Element Analysis **5 Hrs.**

Solution of Dynamic Analysis, Plane Elasticity and Thermal Problems using Finite Elements Analysis

Max. 42 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Recall** the fundamental theory of FEM and concepts behind formulation methods in FEM.

CO2 – **Explain** the role and significance of variational methods considering linear, quadratic, and cubic shape functions.

CO3 - **Modify** the real world problems to 1D, 2D and 3D cases of finite element analysis by applying various FEA elements such as bars, beams, plane and iso-parametric elements.

CO4 – **Analyse** the bars, trusses, beams, heat transfer, fluid flow, and dynamic problems using suitable boundary conditions to a local as well as global equations.

CO5 – **Estimate** the deflections, stresses, and strains induced during failure of various components.

CO6 – **Formulate** and **simulate** various mechanical components subjected to different loading conditions using FEM.

TEXT/REFERENCE BOOKS

1. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill Publication(2003)
2. L.S. Segerlind, Applied Finite Element Analysis, John Wiley & Sons, 1976
3. S.S. Rao, The Finite Element Method in Engineering, Pergamon, 2013

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 Questions of 2 marks each-No choice	10 Marks
4 Questions of 5 marks each-No choice	20 Marks
5 Questions of 10 marks each-one choice and 1 question of 20 marks	70 Marks

20ME411P					Finite Element Analysis Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	-	2	1	2	--	--	--	25	25	50

COURSE OBJECTIVES

- To learn the theory and characteristics of finite element methods.
- To solve problems of 1D, 2D, and 3D using FEA.
- To learn and solve problems of static, thermal, and dynamic problems.

Experiment No	Content
1	An introduction to software, stages of analysis, user interface, convergence testing, saving/restoring jobs, and importing/exporting.
2	Analysis of one dimensions problems
3	Analysis of Two Dimensional Problems: Plane stress and Plane strain
4	Analysis of Three Dimensional Problems: Static Analysis
5	Analysis of thermal Problems
7	Post Processing and interpretation
8	Major Project

Max Hours: 26

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Recall** the fundamental theory of FEM and concepts behind formulation methods in FEM.

CO2 – **Explain** the role and significance of various elements/mesh used in FEA.

CO3 - **Modify** the real world problems to 1D, 2D and 3D cases of finite element analysis by applying various FEA elements such as bars, beams, plane, iso-parametric elements and solid elements.

CO4 – **Analyse** the bars, trusses, beams, heat transfer, fluid flow, and dynamic problems using suitable boundary conditions to a local as well as global equations.

CO5 – **Estimate** the deflections, stresses, and strains induced during failure of various components.

CO6 – **Formulate** and **simulate** various mechanical components subjected to different loading conditions using FEM.

TEXT/REFERENCE BOOKS

1. J.N. Reddy, An Introduction to Finite Element Method, McGraw Hill Publication(2003)
2. L.S. Segerlind, Applied Finite Element Analysis, John Wiley & Sons, 1976
3. S.S. Rao, The Finite Element Method in Engineering, Pergamon, 2013

LAB EXAMINATION PATTERN

Max. Marks: 50	**Exam duration: 2 hrs**
Lab work	25 Marks
Lab Exam	25 Marks

20ME412T					Welding for Metal Joining, Surfacing and Additive Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To Understand various basic and advanced welding processes and its applications
- To learn importance of welding position, edge preparation and testing of welded joints
- To study welding metallurgy of ferrous and non ferrous materials
- To analyse various cutting, cladding, hard facing and additive manufacture operations
- To review automation and robotics systems for welding operations

UNIT 1 Basic of arc welding processes **6 Hrs.**

Importance and classification of metal joining processes. Physic of arc, power source characteristics. Metal transfer, force acting on the arc, different mode of metal transfer, heat & fluid flow in welding. SMAW, SAW, GTAW, GMAW, Basics, application, advantages and disadvantages, pulsed and synergic welding.

UNIT 2 Resistance, Beam and solid state welding processes **12 Hrs.**

Resistance, Beam and solid state welding processes; Types of processes, Fundamental principles of operation, process characteristics and applications. Heat generation, effect of variables equipment details in typical set up, advantages and disadvantages, applications. Electro slag and electro gas welding.

UNIT 3 Advanced Welding and cutting Processes **12 Hrs.**

New Development in Fusion welding processes; Activated Flux TIG process, Metal Core Arc Welding, Flux Core Arc Welding. Narrow Gap Welding processes, Hybrid Welding processes; Underwater welding & repair, cladding and surfacing. Weldability of ferrous and non ferrous systems. Testing of welds and welding defects and significance. Cutting Processes- Gas Cutting, Plasma cutting, Water jet cutting, Laser cutting; welding symbols and welding positions.

UNIT 4 Importance of cladding, hard facing , automation and additive manufacturing in welding **10 Hrs.**

Various cladding and hard facing processes , various types of automation and robotics system applicable in advanced welding processes. Importance of health and safety in various welding processes. Welding processes for additive manufacturing includes wire and arc additive manufacturing, cold metal transfer and friction stir welding for additive manufacturing and other solid state additive manufacturing.

Max. 40 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1 - **Demonstrate** the Various Metal Joining Processes.
CO2 - **Classify** the science behind the welding Arc, Beam, Metal transfer and Heat & Fluid flow.
CO3 - **Evaluate** the various advanced welding process, applications, defects, weldability and testing.
CO4 - **Analyze** the various cutting and cladding methods.
CO5 - **Apply** the concept of automation, robotics and virtual welding
CO6 - **Survey** the health and safety of various welding processes

TEXT/REFERENCE BOOKS

1. Nasir Ahmed ,New Development in Advance Welding, publishers, Wood head publishing Limited, England, 2007
2. John Norrish, Advance Welding Processes- Technologies and Process Control' Wood head publishing Limited, England, 2006
3. Welding Hand Book Eight edition, Vol. 1, American Welding Society
4. J Vora, V J Badheka, Advances in Welding Technologies for Process Development ,CRC Press, 2019.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 16 Questions 5 Marks Each	80 Marks
Part B/Question: 10 Short Questions 2 Marks Each	20 Marks

20ME412P					Welding for Metal Joining, Surfacing and Additive Manufacturing Lab					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	2	1	2	--	--	--	50	50	100

COURSE OBJECTIVES

- To learn the practical significance of different types of advanced welding processes
- To develop an understanding on the effect of welding variables on weld bead profile.
- To study the various defects under different types welding processes
- To correlate welding processes for surfacing and additive manufacturing

List of experiments

1. Evaluate various flux assisted TIG welding processes on basis of weld bead profile
2. Effect of various consumables like solid, flux cored and metal cored on basis of bead profile.
3. Understand design and construction of various narrow gap welding torches.
4. Effect of ultrasonic welding variables on similar and dissimilar metal combinations
5. Effect of pulse parameters on weld bead profile.
6. To understand the importance of tool pin offset and material positioning under Friction stir welding of dissimilar metals and materials combination
7. Friction stir welding using bobbin tool and scribe tool
8. Comparing TIG Cladding using cold wire and hot wire
9. Solid state cladding using Fiction surfacing of Aluminium on steel
10. Arc Welding processes for Wire arc additive manufacturing
11. Various NDT and DT for welded joints.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Demonstrate the working principles and operations of various welding processes
CO2 - Analyse the effect of different welding parameters on the weld bead profile.
CO3 - Demonstrate the significance of different welding methods for various applications
CO4 - Judge the uses of different welding techniques for surfacing and additive manufacturing applications.
CO5 - Appraise the limitations of each technique.
CO6 - Survey the health and safety of various welding processes

TEXT/REFERENCE BOOKS

1. Nasir Ahmed ,New Development in Advance Welding, publishers, Wood head publishing Limited, England, 2007
2. John Norrish, Advance Welding Processes- Technologies and Process Control' Wood head publishing Limited, England, 2006
3. Welding Hand Book Eight edition, Vol. 1, American Welding Society
4. J Vora, V J Badheka, Advances in Welding Technologies for Process Development ,CRC Press, 2019.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 25	**Exam Duration: 2 Hrs**
Quiz	10 Marks
Viva	15 Marks

19ME 401T					Machine Design-II					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0		3	3	25	50	25	--	--	100

Prerequisites: Strength of Materials, Machine Design-1

COURSE OBJECTIVES

- To impart knowledge on design to various force transmission elements like gears and bearings
- To provide the knowledge of various Industrial material handling devices
- To appreciate the knowledge of design of an industrial gear box

UNIT 1: Design of Gear Drives **12 Hrs.**

Gear terminology, Kinematics of gear drive, Standard system of gear tooth, Gear materials, Design of Spur, helical and bevel gears

UNIT 2: Design of Bearings **12 Hrs.**

Materials and selection of bearings, Working conditions for the bearings, Hydrodynamic lubrication theory for journal bearings, Design factors, Design procedure, Design of bearings, Ball and roller bearings, Load and life rating

UNIT 3: Design of Gear Box **10 Hrs.**

Geometric progression- standard step ratio, sliding mesh gear box, constant mesh gear box, synchromesh gearbox, multi speed gear box

UNIT 4: Design of Material Handling Equipment **11 Hrs.**

Introduction of material handling equipment, Concept of material handling system design, design of ropes, hooks

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Design** bearings that are used in various engineering and commercial applications
CO2 - **Design** gears that are used in various engineering and commercial applications
CO3 - **Identify** the concept of materials handling systems in industries
CO4 - **Design** various components namely rope and crane hook for their safe use
CO5 - **Design** gear box after understanding the concepts of various types of gear drives
CO6 - **Evaluate** the various design and failure criterion as per the industry standards

TEXT/REFERENCE BOOKS

1. MC. Sharma and K. Purohit, Design of Machine Elements, PHI Publishers.
2. U. Jindal, Machine Design, Pearson Publishers
3. J. Shigley, C. Mischke, R. Budynas, Mechanical Engineering Design, Tata-McGraw Hill
4. R. Norton, Machine Design: An Integrated Approach, Pearson Education Publishers
5. V. Bhandari, Machine Design, Tata-McGraw Hill Publishers

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 4 Questions (10 Marks Each) 40 Marks
Part B/Question: 5 Questions (12 Marks Each) 60 Marks

20ME401P					Machine Design -II lab		
Teaching Scheme					Examination Scheme		
L	T	P	C	Hrs/Week	Practical		Total Marks
					Continuous Evaluation	End Semester	
--	--	2	1	2	**25**	**25**	**50**

COURSE OBJECTIVES

- To define mechanical problem and learn mathematical formulation.
- To learn Matlab coding, CAD modelling and ANSYS software.
- To perform analysis and interpret the results.

PART A: Minor Project

List of Design Problems: Manual design, Computer program and solid model using CREO

1. Design exercise for Spur/Helical gears
2. Design exercise for Bevel/Worm gears
3. Design exercise for Bearings
4. Design exercise for Gear boxes
5. Design exercise for Material Handling equipment
6. Design exercise for various other machine elements lie chain drive, pulley drive, belt drives, rope design etc.

PART B: Major Project

Consist of:

1. Conduct FEA analysis and understand the results. Visit of any one industry identified
2. Manual Design of the major design
3. Preparation of the Computer program for the design (for parametric analysis and optimization)
4. Preparation of the solid model, detail and assembly drawings using software
5. Analysis of the parts using FEA software
6. Preparation of the report

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Recall** and **List** the programming, modelling and analysis software.

CO2 - **Classify** different types of analysis that can be performed on mechanical components.

CO3 - **Prepare** problem and **Solve** mathematical equations for simple interdisciplinary problem.

CO4 - Conduct FEA analysis and **analyze** the findings obtain through Matlab and FEA.

CO5 - **Compare** the results obtain using Matlab and ANSYS.

CO6 - **Design** and **Develop** Matlab code, CAD model and perform analysis for a real life problem of society.

TEXT/REFERENCE BOOKS

1. Rudra Pratap, Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers, Oxford University Press, 2010.
2. Steven C. Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 3rd Edition, Tata McGraw-Hill Education, 2011.
3. Mary K. Thompson & John M. Thompson, ANSYS Mechanical APDL for Finite Element Analysis, 1st Edition, Butterworth-Heinemann, 2017.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 50 **Exam Duration: 2 Hrs**

Part A : Presentation based on Project 25 Marks

Part B : Viva 25 Marks

20ME413T					Thermal Analysis and CFD of Manufacturing Processes					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	4	4	25	50	25	--	--	100

COURSE OBJECTIVES

- To **formulate** the mathematical models for different manufacturing processes.
- To Solve and **analyse** different mathematical models or different manufacturing processes.
- To **understand** and **apply** different numerical techniques for solidification processes. .
- To **demonstrate** the ability to use modern CFD software tools to analyse solidification processes.

UNIT 1 Solidification physics and transport in Solidification processes. 10 Hrs.

Introduction to transport phenomena in materials processing:heat-transfer, momentum transport, mass transport, solidification, and microstructure development. Fundamentals of Solidification: Importance of solidification, Nucleation and growth, Pure metal solidification, Gibbs Thomson effect, Alloy Solidification: Mathematical Analysis of redistribution of solute during solidification, Constitutional under cooling,, Morphological instability of solid-liquid interface, Dendrites growth , Multi phase solidification.

UNIT 2 Mathematical modelling and solution approaches 10Hrs.

Mathematical modelling of different manufacturing processes, considerations in transport phenomena associated with materials processing, Governing equations and Boundary condition for transport phenomena in solidification based manufacturing processes like casting, welding, Melting, surface remelting, soldering, crystal growth, metal purification, polymer extrusion and molding, etc. Solutions procedure and theoretical analysis by Analytical methods , scaling analysis, perturbation techniques, Numerical approach for solving manufacturing problems. CFD tool, Finite-difference Method.

UNIT 3 Finite Volume Method and Solidification melting modules 10Hrs.

Finite volume method for general transport convection/diffusion equations. Discretization of transient, advection, diffusion and source terms, and spatial discretization of domain. Solution stratergies for solving of system of algebric equations, resiual error, convergence, under-relaxation. Pressure-velocity coupling. Numerical models for handling solid-liquid interface: Enthalpy-porosity apprach, VOF approach, Phase-field etc.

UNIT 4 Simulations and analysis for manufacturing processes 10 Hrs.

Case-studies: Thermal simulations and analysis for manufacturing processes with phase-change. Verifiaction, validation and benchmarking. Cases with continous material processing, Inverse heat transfer problems, combined simulation and experimenatl approach for complex manufacturing problems. Introduction to multi-physics and multi-scale models of solidification based manufacturing problems. Micro/meso scale transport models for microstructure modelling.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – To **formulate** the mathematical model for solidification based manufacturing processes

CO2 – **Apply** therotical (analytical, order-of-magnitude anlysis, etc) tools for analysing manufacturing problems.

CO3 – **Choose**, Understand, implement appropriate numerical solidification model to solve manufacturing problems.

CO4 – **Choose and Justify** the CFD schemes for the respective fluid flow/transport phenomena problem.

CO5 - **Perform** verification and validation of numerical model.

CO6 - **Demonstrate** the ability to use modern CFD software tools.

TEXT/REFERENCE BOOKS

1. Solidification,J. A. Dantzig and M. Rappaz, EPFL Press, 216.
2. Jaluria, Yogesh. *Advanced materials processing and manufacturing*. Cham, Switzerland: Springer, 2018.
3. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.
4. *Science and engineering of casting solidification*. Stefanescu, Doru Michael. Springer, 2015.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 10 Questions from unit I and Unit II	25 Marks
Part B/Question: 15 Questions from Unit III (Unit IV will be counted in IA)	75 Marks

20ME413P					Thermal Analysis and CFD of Manufacturing Processes Lab.					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	2	1	2	--	--	--	25	25	50

COURSE OBJECTIVES

- To perform experimental, thermotical, numerical study of manufacturing process.
- To develop an ability in student to formulate numerical models and conduct numerical experiments on solidification-based manufacturing processes.
- To study different CFD model/schemes/tools for solving and analysing solidification-based manufacturing processes.
- To compare experimental, thermotical and numerical results for the studied solidification process.
- To verify and validate the numerical models of manufacturing process.

LIST OF EXPERIMENTS

1. Experimental study and thermal analysis (theoretical/numerical) of casting process.
2. Experimental study and thermal analysis (theoretical/numerical) of surface remelting /welding (any moving heat source) process.
3. Experimental study and thermal analysis (theoretical/numerical) of solidification or melting of PCM.
4. Computational study and validation of 1D conduction model for a heat transfer problem.
5. Computational study and validation of 2D conduction based heat transfer problem.
6. Computational study and validation of 1D/2D conduction based casting/moving heat source problem.
7. Numerical study to 2D natural convection in a casting problem
8. Numerical study to 2D Marangoni or Benard convection.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: To **formulate** the mathematical model, discretise and numerically solve the governing equation for solidification-based manufacturing processes.

CO2: To **plan** and **conduct** experiments on manufacturing processes, identify and perform critical experimental procedures to isolate the experimental errors.

CO3: Identify the critical take-away from the experimental study/results to the numerical model/results as a input to mathematical model, or boundary conditions.

CO4: To **perform** pre-processing /post-processing of CFD models/results

CO5: To **constructs** CFD models/programs for simulation of manufacturing process.

CO6: To **record**, **organize** and **analyse** the experimental/computational results to interpret and **report** the physics in the transport phenomena for the respective manufacturing process.

TEXT/REFERENCE BOOKS

1. The Finite Volume Method in Computational Fluid Dynamics: An Advanced Introduction with OpenFOAM® and Matlab, F. Moukalled, L. Mangani, and M. Darwish, Springer, 2015..
2. Jaluria, Yogesh. *Advanced materials processing and manufacturing*. Cham, Switzerland: Springer, 2018.
3. Introduction to Computational Fluid Dynamics: The Finite Volume Method, Versteeg, H. K. and Malalasekara, W., Second Edition (Indian Reprint) Pearson Education, 2008.
4. *Science and engineering of casting solidification*. Stefanescu, Doru Michael. Springer, 2015.

END SEMESTER LAB EXAMINATION

Max. Marks	**Exam Duration: 2 hrs**
Quiz/Experiment	10 Marks
Viva	15 Marks

20ME414T					Two Phase Flow and Heat Transfer					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To describe two phase flow patterns in presence of heat transfer
- To gain fundamental understanding of two phase flow with heat transfer
- To introduce methods of analysis of two phase flows with and without phase change.

UNIT 1 FUNDAMENTALS OF TWO PHASE FLOW **10 Hrs.**

Introduction and Review of Single Phase Flow, Laminar Forced Convection Single Phase Heat Transfer, Single Phase Natural Convection, Turbulent Forced Convection Single Phase Heat Transfer. Review of one-dimensional conservation equations in single phase flows; Governing equations for homogeneous, separated and drift-flux models; Flow pattern maps for horizontal and vertical systems; Simplified treatment of stratified, bubbly, slug and annular flows.

UNIT 2 BOILING AND CONDENSATION **13 Hrs.**

Phase Change Principles And Fundamentals Of Boiling: Description and Classification of Boiling, Pool Boiling Curve, Nucleation and Dynamics of Single Bubbles, Heat Transfer Mechanisms in Nucleate Boiling, Nucleate Boiling Correlations, Hydrodynamic of Pool Boiling Process, Pool Boiling Crisis, Film Boiling Fundamentals, Flow Boiling, Forced-Flow Boiling Regimes, Flow Boiling Curves, Nucleate Boiling in Flow, Subcooled Nucleate Flow Boiling, Saturated Nucleate Flow Boiling, Flow Boiling Correlations, Flow Boiling Crisis. Condensation: Film wise condensation**:** Laminar condensation of vapor, Condensation on tube banks and Numerical. Drop wise Condensation: Factors effecting of condensation of steam

UNIT 3 TWO-PHASE FLOW WITH HEAT TRANSFER **12 Hrs.**

Two-Phase Flow Pressure Drop Fundamentals, Two-Phase Multiplier for Homogeneous Flow, Two-Phase Multiplier for Annular Flow (Martinelli-Nelson), Computational Algorithm for Two-Phase Flow in Pipes, Friction Pressure Loss in Subcooled Nucleate Boiling, Heat Transfer in Internal Two-Phase Flow.

10 Hrs.

UNIT 4 SPECIAL TOPICS IN TWO-PHASE FLOW AND HEAT TRANSFER

Critical Heat Flux (CHF) in Internal Two-Phase Flow, Flow Instability in Internal Two-Phase Flow, Two-Phase Flow Through Orifices, Cavitation in Fluid Components, Two-Component Two-Phase Flows, Pressure Relief Line Flow

Max. 45 Hrs.

COURSE OUTCOMES (CO's):

On completion of the course, student will be able to

CO-1: Describe two-phase flow patterns with and without heat transfer

CO-2: Understand different flow pattern and its instability with bubble behavior

CO-3: Analyze pool and flow boiling phenomena to design the heat dissipative cooling equipments

CO-4: Analyze condensation phenomena in the industrial equipments

CO-5: Explain effect of two-phase flow with heat transfer on system pressure

CO-6: Identify conditions for cavitation

TEXT/REFERENCE BOOKS

1. Ghiaasiaan, S. M., Two-Phase flow, Boiling, and Condensation, Cambridge University Press, 2007.
2. Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press, 2005.
3. Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, Oxford University Press, 1996
3. L. S. Tong and Y. S. Tang, Boiling Heat Transfer and Two-Phase Flow, Taylor and Francis, 1997
4. M. Ishii and T. Hibiki, Thermo-Fluid Dynamics of Two-Phase Flow, Springer, 2010.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

10 Questions each of 10 marks from above units with appropriate marks distribution among designed Course Outcomes (COs) 100 Marks

Pandit Deendayal Energy University **School of Technology**

20ME415T					Advanced Heat Transfer					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- 1 To study and analyse the basics of three modes of Heat Transfer (HT).
- 2 Apply scientific and engineering principles to analyse and design HT aspects of engineering systems.
- 3 Study and apply different solution methods and choose appropriate analytical or approximate or order-of-magnitude-analysis or computational tools to investigate heat transport phenomena.
- 4 To develop HT models and computational strategies to solve and analyse the HT physics.

UNIT 1 Conduction heat transfer **10 Hrs.**

Conduction: Conservation equations and different boundary conditions;; Generic 3D and unsteady conduction equation in Cartesian, Cylindrical and spherical Co-ordinate System. 1D, 2D steady and unsteady conduction problems with different solution methods – analytical, approximate and numerical solutions. Derivation of conduction based conservation equations for anisotropic material.

UNIT 2 Radiation heat transfer **10 Hrs.**

Introduction to Radiation Heat Transfer (RHT), laws of RHT, Solid angle, radiation from a black body, Radiation intensity, Radiation heat flux, radiation properties of non-black opaque surfaces, shape factors for uniform diffuse radiation, radiation exchange in gray diffuse enclosures, Network method for multi-surface enclosures. Different solution approach for RHT.

UNIT 3 Forced Convection heat transfer **10 Hrs.**

Governing equation for convection heat transport. Analytical, approximate and numerical solutions procedures for External and internal forced convection: heat transfer in laminar flows, concept of hydrodynamically and thermally developed and developing flows, flow over flat plates with low and high Prandtl number approximations. Application of empirical correlations to estimate Nusselt Number/heat-transfer coefficient.

UNIT 4 Free Convection ; Complex and Multi-mode heat transfer problems. **10 Hrs.**

Free convection: Free convection boundary layer equations, Analytical, approximate and numerical solutions procedures for internal and external free convection; Rayleigh-Benard convection, Onset of convection. Application of empirical correlations to estimate Nusselt Number/heat-transfer coefficient. Complex and Multi-mode heat transfer: Radiation with participating medium with/without flow, the engineering treatment of gas radiation in enclosures. Phase-change heat transfer. Multi-mode heat-transfer problems. Turbulent heat transfer.

Total: 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to,

CO1 - **Understand** and **apply** the basic concept of conduction, convection and radiation heat transfer.
CO2 – **Sketch** the equivalent-thermal-circuit/simplified-HT-system to **solve** and **analyse** complex HT problems.
CO3 – **Choose/Derive/Formulate** the right governing equation and solution procedure for Complex HT problems.
CO4 – **Formulate** and/or **apply** the numerical strategy to solve heat transfer problem
CO5 – **Compare** the magnitude of different terms in Governing Equation (GE) and **construct** and solve simplified GE.
CO6 – **Evaluate** the Radiation heat transfer in engineering system with/without participating medium.

TEXT/REFERENCE BOOKS

1. Conduction Heat Transfer, V.S. Arpaci, Addison Wesley, 1996 (Abridged edition Ginn press 1998)
2. Burmeister, Louis C. Convective heat transfer. John Wiley & Sons, 1993.
3. Bejan, Adrian. Convection heat transfer. John wiley & sons, 2013.
4. Radiative Heat Transfer, M.F.Modest, McGraw Hill, 2003.
5. Bergman, T. L., Incropera, F. P., *et. al.* (2011). Introduction to heat transfer. John Wiley & Sons.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/ Four questions (One from each unit) 20 Marks
Part B/ Four questions (One from each unit) 80 Marks

20ME416T					Advances in Fluid Mechanics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of obtaining the governing equation of various types of fluid flow.
- To obtain the exact solution for the laminar flows.
- To obtain the solution for potential and compressible fluid flow

UNIT 1 Differential and Integral form of governing equations (8)

Velocity field, Lagrangian and Eulerian Description, Velocity gradients; Strain Rates in fluids, Velocity Potential, Stream Function, Streamlines, Path lines, Vorticity, Circulation, Recap of Tensor notations, basic Tensor algebra and Calculus, Concept of continuum, Reynolds transport theorem RTT, Control volume approach etc. Concept of Stress; Stress as a Tensor; The Traction Vector; The Cauchy Momentum Equation; Constitutive Equation, Derivation of Governing Partial Differential Equations: Derivation of Continuity, Momentum and Energy equation Fluxes in Navier-Stokes Equation, Non dimensional N-S Equation, Initial and Boundary conditions.

UNIT 2 Exact solution of fluid flow and Vorticity dynamics (11)

Exact solution of Navier –Stokes Equation: Introduction, Fully developed flow, Developing flow in parallel channel, Unsteady flow in a long tube, stokes first and second problem.

Vorticity Dynamics: Introduction, vortex lines and tubes, Role of viscosity in Rotational and Irrotational flow, Kelvin's circulation theorem, Vorticity Equation in a Non rotating Frame, Vorticity Equation in a Rotating Frame, Interaction of vortices.

UNIT 3 Potential flow and laminar boundary layer (12)

Potential flow theory: Incompressible-Inviscid flow, Numerical solution of plane Inviscid flow, Complex variables ,simple potential flows like uniform flow, Irrotational vortex, source, sink, doublet, flow past a half body, cylinder and cylinder with circulation, Laminar Boundary Layers: Ideal and Boundary Layer Theory, Prandtl's Model of boundary layer flow, order of magnitude analysis, flow over flat plate, Blasius solution for flow over flat plate, Boundary layer with non zero pressure gradient, Momentum integral approach, Karman-pohalhausen method for flat plat and duct, Separation and its prevention.

UNIT 4 Turbulent and compressible fluid flow (11)

Turbulent Flow: Concept of linearized stability of parallel viscous flow, transition to turbulent flow, Reynolds equation for turbulent flow, Reynolds stresses, Prandtl's mixing length theory, velocity profile, Turbulent flow in pipes, turbulent boundary layer on flat plate.

Compressible Flow: Introduction, one dimensional compressible gas flow, flow in nozzle, effect of viscous friction and heat transfer, shocks in supersonic flow, Normal and oblique shocks

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Derive, **Analyse** and Compare differential and integral form of governing equation of fluid flows.
CO2: **Develop** the vorticity dynamics and obtain the exact solution of specific fluid flow cases.
CO3: **Illustrate** the governing equation of various potential flow and evaluate it analytically
CO4: **Determine** the laminar boundary layer and obtain the solution for laminar boundary layer problem.
CO5: **Outline** the turbulent fluid flow and analyse the turbulent fluid flow through pipes.
CO6: **Analyse** and **evaluate** the compressible fluid flow through the nozzle.

TEXT/REFERENCE BOOKS

1. K Muralidhar, G Biswas Advanced Engineering Fluid Mechanics, Narosa Publishing, 2005
2. PK Kundu, IM Cohen, Fluid Mechanics, Academic press, 2001
3. H. Ockendon, JR Ockendon, Viscous flow, Cambridge university press. 1995
4. Schlichting & Gersten, Boundary Layer Theory. 2016
5. Tennekes & Lumley A first course in Turbulence. 1972

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part B/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME417T					Cryogenics					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of production and maintaining low temperature and its application
- To explain various cryogenic liquification system and obtain its comparative performance
- To explain the various cryorefrigerator and evaluate its performance

UNIT 1 **(10L)**

Introduction to Cryogenic engineering, properties of cryogenic fluids like Oxygen, Nitrogen, Argon, Neon, Florin, Helium, Hydrogen, Safety in handling of cryogens, Properties of material at cryogenic temperature- mechanical, thermal, electrical, Super conductivity, formation of superconductivity, super conducting material behaviour, application of cryogenic systems in space, medical, industries, biological, Super conductive devices such as bearings, motors, cryotrons, magnets, D.C. transformers, space simulation,

UNIT 2 **(10L)**

Introduction, thermodynamically ideal systems and its performance assessment, J-T effect and analysis, inversion curve and its importance, liquefaction systems for oxygen, nitrogen, air, hydrogen, helium etc., assessment of its performance parameters, parametric analysis of the system and its effect of performance parameter, comparison of all such systems based on the performance parameters.

UNIT 3 **(10L)**

Thermodynamically ideal refrigeration cycles, simple and precooled J-T refrigerator, expander based refrigeration system, Cry coolers: Sterling refrigerator, regenerator and its effect on the performance of sterling refrigerator, single and double volume G-M refrigerator, performance comparison between sterling and G-M refrigerator, pulse tube refrigerators, adiabatic magnetization and demagnetization, magnetic refrigerator, dilution refrigerator

UNIT 4 **(10L)**

Cryogenic insulation – expanded foams, gas filled & fibrous insulation, vacuum insulation, evacuated powder & fibrous insulation, opacified powder insulation, multilayer insulation, comparison of performance of various insulations. Dewar vessel for storage of cryogenic liquid.

Lecture: 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Recall and list the properties of cryogenic fluids and application of cryogenics.
CO2: Identify the behaviour of material properties at low temperature and its application.
CO3: Assess the construction and working of various cryogenic liquification systems
CO4: Identify the construction and working of various cryorefrigerator
CO5: Compare and analysed the performance of various cryogenic liquification and refrigeration system
CO6: Analyse the various cryogenics insulations and evaluate its performance.

TEXT/REFERENCE BOOKS

1. Cryogenic systems, R F Barron, Oxford University Press
2. Cryogenics: A Text Book, S. S. Thipse, Alpha Science Intl Ltd
3. Cryogenic technology & applications, A R Jha, Butterworth-Heinemann.
4. Cryocooler, Fundamentals Part I &II, Graham Walker, Plenum Press, New York.
5. Fundamentals Of Cryogenic Engineering, Mamata Mukhopadhyay, PHI.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME418T					Heating, Ventilation and Air Conditioning					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop the human recourse and skills in HVAC industries
- To understand concepts and design of HVAC equipment
- To create several self-employment opportunities in HVAC market within country and overseas.

UNIT 1 HVAC introduction **(08)**

HVAC introduction: Overview of Industry and Scope of HVAC, applications of HAVC, definitions and terminology, Overview of Psychrometry

UNIT 2 Human comfort and cooling-heating load esrimation **(12)**

Human Comfort: Heat transfer from body, convection, radiation, conduction, evaporation, clothing resistance, activity level - Concept of human comfort – Thermal response - comfort factors – Environmental indices - Indoor air quality. Cooing Load Estimation: External load – solar radiations, wall, roof and glass etc.; internal load – occupancy, lighting, equipments; Ventilation - air quantity; Load estimation methods - Equivalent Temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Heating load estimation: Vapour transfer in wall, vapour barrier, and load estimation basics.

UNIT 3 Air Distribution **(11)**

Air Distribution: Ducts, Types of ducts, Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, methods of sizing and balancing. Ventilation: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load.

UNIT 4 Air conditioning systems **(11)**

Classification, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms etc

Max: 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1- **Classify** phenomenon of sensible heating and cooling

CO2- **Discover** and study the importance of Psychometric chart in HVAC

CO3- **Analyze** importance of HVAC in industrial applications

CO4- **Estimate** importance of duct material and design in transporting cool air

CO5- **Apply** awareness of HVAC fundamentals.

CO6– **Deduce** different techniques to save energy in HVAC applications.

TEXT/REFERENCE BOOKS

1. Refrigeration and Air Conditioning, Stoecker, W.F., and Jones, J.W., 2nd Edition, Tata McGraw Hill, New Delhi 1982.
2. Refrigeration and Air Conditioning, Arora, C.P., Tata-McGraw- Hill, New Delhi, 2003.
3. Heating, Ventilating and Air Conditioning-Analysis and Design, McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey, 5th ed. John Wiley & Sons, 2000.
4. Air conditioning and ventilation of buildings, Croome, D.J. and Roberts, B.M., Pergamon.
5. Industrial Ventilation Application Handbook, ISHRAE

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME419T					Hybrid Power Generation Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To develop an insight and understanding on different power generation methods
- Impart knowledge on energy and environment management using hybrid systems
- To assess the impact of implementing hybrid systems in industries and households
- To inculcate knowledge and skills to identify, formulate and solve fields problem in a multi-disciplinary frame individually or as a member of a group

UNIT 1: GENERAL ASPECTS AND KNOWLEDGE BASE ON POWER GENERATION (12 Hrs)

Energy Scenario: Primary & Secondary energy, Non-renewable & renewable energy, Globally energy reserves and production,

Power Generation methods: Coal power plants, Nuclear Power Plants, Gas turbine Power Plants, Solar Power Plants, Wind turbines

UNIT 2: HYBRID SOLAR SYSTEMS (12 Hrs)

Solar power generation methods; Need for solar hybrid energy system; Methods to overcome intermittence in solar power: on/off grid solar power, solar power generation integrated with storage; hybrid model of solar and diesel energy system, Solar-wind-diesel hybrid system

UNIT 3: HYBRID RENEWABLE ENERGY SYSTEMS (HRES) (10 Hrs)

Need and advantages of HRES; hybrid solar thermal and wind energy system; hybrid solar PV and wind energy system; Biomass-wind-fuel cell hybrid; Policies for hybrid systems; Case studies

UNIT 4: HYBRID SYSTEM INTEGRATION, ASSESSMENT AND IMPACT (10 Hrs)

Software based simulation to understand the hybrid power systems response; financial feasibility assessment of a hybrid system; analysis of various existing and potential incentives for promoting renewable energy utilization: carbon credit etc.; future economic and environmental scenarios leading to shift towards hybrid power generation

[Total : 42 Hrs]

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Define** energy, its types and **list** out different power generation methods
CO2: **Illustrate** the need for hybrid systems for solar power generation
CO3: **Identify** opportunities for enabling rational use of hybrid energy technology in supply and demand perspective
CO4: **Inspect** and analyze the performance of hybrid systems
CO5: **Assess** and recommend hybrid technology based on the location
CO6: **Develop** skills to create innovative hybrid solutions, and propose and estimate potential incentives of implementing the same

TEXT/REFERENCE BOOKS

6. Mukund R Patel, "Wind and Solar Power Systems", CRC Press, 2004.
7. Ali Keyhani, "Design of Smart Power Grid Renewable Energy Systems", Wiley, 2016
8. Clark W. Gellings, "The Smart Grid: Enabling Energy Efficiency and Demand Response", CRC Press , 2009
9. S Sumathi, Ashok Kumar L, S Sureka, "Solar PV and Wind Energy Conversion Systems - An Introduction to Theory, Modeling with MATLAB/SIMULINK, and the Role of Soft Computing Techniques", Green Energy and Technology, Springer; 2015.
5. Lopez, N., and Espiritu, J. F., 2011, "An Approach to Hybrid Power Systems Integration Considering Different Renewable Energy Technologies," Procedia Comput. Sci., **6**, pp. 463–468.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Unit 1/Question: <Question 1 with subsections(with internal choice)>	<20> Marks
Unit 2/Question: < Question 2 with subsections(with internal choice)>	<20> Marks
Unit 3/Question: <Question 3 with subsections(with internal choice)>	<30> Marks
Unit 4/Question: < Question 4 with subsections(with internal choice)>	<30> Marks

20ME420T					Phase Change Materials: Technologies and Application					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To provide an insight into various phase change materials (PCMs) and their classification
- Discuss the scientific principles underpinning the operation of PCMs based systems
- To impart knowledge on construction, working and performance analysis of different PCM based systems
- To develop skills to find solutions to engineering problems using PCMs to achieve energy conservation and energy efficient operation in systems

UNIT 1: INTRODUCTION TO PHASE CHANGE MATERIALS (PCMs) [8 Hrs]

Introduction; PCM Classification, Non-commercial/commercial materials; Thermophysical properties and methods of determination; Long-term stability, methods of PCM enhancement; Application potential

UNIT 2: PCM AS STORAGE FOR SOLAR THERMAL SYSTEMS [10 Hrs]

SHS (Sensible Heat Storage) mediums; Stratified storage systems; Rock-bed storage systems; Advantage of PCMs (Latent Heat Thermal Energy systems, LHTES) over SHS mediums; Selection criteria of PCMs; Thermal Modelling of PCM assisted Flat Plate Collectors (FPC) and Evacuated Tube Collectors (ETC); LHTE systems for solar thermal power generation to resolve intermittency in solar applications and calculations; Case studies; Storage for geothermal energy storage systems

UNIT 3: PCM SYSTEM INTEGRATION AND OPTIMIZATION [12 Hrs]

Basics of optimization; PCM system integration; Optimization of PCM assisted application; Integration of PCMs within buildings; Thermal Modelling of PCM incorporated building envelop; PCM based Battery thermal Management System (BTMS); Cost Analysis

UNIT 4: APPLICATION POTENTIAL OF PCM [10 Hrs]

Constant temperature solar water heating for swimming pools and process heating; Constant temperature crop drying; Temperature regulation and control in Buildings; Temperature control of PV modules; Thermal Regulation for Electronic circuits; Case studies

[Total : 40 Hrs]

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **List** and **define** various types of PCMs and their classification

CO2: **Outline** different solar thermal storage options using PCMs and **compare** sensible and latent heat storage systems for a given application

CO3: **Apply** knowledge of PCMs for enhanced performance of different PCM integrated systems

CO4: **Analyse** the impact of having PCM for various applications

CO5: **Compare** and **select** PCMs for resolving the intermittency of renewable energy sources, such as solar and other storage applications

CO6: **Design** and **develop** innovative energy efficient solutions using PCM

TEXT/REFERENCE BOOKS

1. Fleischer, Amy S, "Thermal Energy Storage Using Phase Change Materials Fundamentals and Applications", Springer 2015.
2. Ibrahim Dincer and Mark A Rosen, "Thermal Energy Storage Systems and Applications", John Wiley and Sons 2011.
3. Zalba, B., Marín, J. M., Cabeza, L. F., and Mehling, H., "Review on Thermal Energy Storage with Phase Change: Materials, Heat Transfer Analysis and Applications," Appl. Therm. Eng., 23(3), pp. 251–283, 2003
4. Stankovic, S., "Investigation of Advanced Experimental and Computational Techniques for Behavioural Characterisation of Phase Change Materials (Pcms)," Ph.D. Thesis, City Univ. London, 2014
5. Ru-shiliu, Leizhang, Xueliang sun, "Electrochemical technologies for energy storage and conversion", Wiley Publications, 2012

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Unit 1/Question: <Question 1 with subsections(with internal choice)>	<20> Marks
Unit 2/Question: < Question 2 with subsections(with internal choice)>	<20> Marks
Unit 3/Question: <Question 3 with subsections(with internal choice)>	<30> Marks
Unit 4/Question: < Question 4 with subsections(with internal choice)>	<30> Marks

20ME421T					Thermal System Design					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To impart the knowledge of various thermal system models and steps involve in thermal system design
- To perform the modeling and optimization of thermal systems
- To estimate the trade-off between energy and economy during thermal system design

UNIT 1 **(10L)**

Introduction, thermal systems, engineering design, workable and optimal designs. primary energy analysis, basic considerations in design, conceptual design, steps in the design process, measurement in thermal system for temperature, pressure, flow, velocity etc.

UNIT 2 **(10L)**

Design criteria: maximum efficiency and energy conservation, minimum cost/losses, multi-criteria, functional reliability of system components, modelling and simulation of thermal systems, types of models with examples, mathematical modelling of processes and components, system models, identification of operating variables; simulation techniques, curve fitting.

UNIT 3 **(12L)**

Design of systems from different application areas, optimization, maximum and minimum conditions, optimization parameters, levels of optimization, mathematical representation of problem, optimization procedures including introduction to some non-traditional methods

UNIT 4 **(10L)**

Economic Considerations: present and future work factors, gradient factors, rates of return, life cycle cost. Dealing with uncertainty-probabilistic techniques, trade-offs between capital & energy using pinch analysis, energy-economy models, economic factor in design, application to thermal systems

Lecture: 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Classify the types & steps involve in the thermal system design.
CO2: Evaluate the modelling of thermal system.
CO3: Demonstrate the various property measurement of thermal system
CO4: Demonstrate the various methods for the optimization of thermal system
CO5: Develop the optimization of thermal design and analysed the effect of geometric/operating parameters
CO6: Analyse the economic aspects of thermal system design

TEXT/REFERENCE BOOKS

1. W.F. Stoecker, Design of Thermal Systems, McGraw Hill
2. Y. Jaluria, Design and Optimization of Thermal Systems, CRC Press
3. R.F. Boehm, Developments in the design of thermal systems, Cambridge University Press
4. S.G. Penoncello, Thermal Energy Systems Design and Analysis, CRC Press

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: Questions from each unit with internal choice, each carrying 20 marks 100 Marks

20ME422T					Waster Heat Recovery					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	0	3	25	50	25	-	-	100

COURSE OBJECTIVES

- To impart the knowledge of importance of waste heat recovery, its advantages and applications
- To study and assess various waste heat recovery systems and understand their working principle
- To understand thermodynamic cycles associated with heat recovery
- To gain the knowledge of phase change material applications in waste heat recovery storage systems.

UNIT 1 **9 Hrs.**

Introduction – Introduction to waste heat recovery, classification and applications of waste heat, Importance and advantage of waste heat recovery – Challenges and Barriers for Waste Heat Recovery, industrial waste heat sources – cement industry, iron & steel industry, glass industry, food industry and ceramic industry.

Recapitulation of thermodynamic cycles, 1st law efficiency, 2nd law efficiency and Exergy efficiency.

UNIT 2 **10 Hrs.**

Waste heat recovery systems – recuperators, regenerators, rotary regenerators (heat wheels), economisers, air preheaters. Plate heat exchangers (PHE), heat pipe systems, heat pipe heat exchanger, heat pumps, direct electrical conversion – thermoelectric generation, piezoelectric power generation, thermo-ionic generator, practical examples of waste heat recovery systems.

UNIT 3 **10 Hrs.**

Thermodynamics cycles for waste heat recovery – Rankine cycle, Brayton cycle, combined Brayton and Rankine cycles – steam and organic, Organic Rankine Cycle & Kalina cycle – working principle, components, organic fluids, advantages and disadvantages, Industrial applications and case studies.

UNIT 4 **10 Hrs.**

Phase Change Material Application for waste heat recovery systems; Design of PCM heat exchanger for heat recovery systems; Tri-generation and Poly-generation concept to minimize heat losses; Thermal modelling and analysis of heat recovery system; Industrial Applications and Case Studies

Total 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - Recall the fundamental need of waste heat recovery and its applications

CO2 – **Identify** potential sources of power generation through different industrial waste heat sources

CO3 – **Understand** heat recovery systems through different technology and evaluate its thermal performance.

CO4 – **Evaluate** thermal efficiency of waste heat recovery cycles and suggest ways to improve the efficiency.

CO5 – **Identify** the need of phase change materials in waste heat recovery systems and discuss merits and demerits

CO6 – **Design** PCM heat exchanger for waste heat recovery systems.

TEXT/REFERENCE BOOKS

1. Vernon L Erikson, “Heat recovery steam generator technology” Woodhead Publishing
2. Ennio Macchi, “Organic Rankine Cycle Power Systems”, Woodhead Publishing
3. Christine Junior, “Energy and Thermal Management, Air conditioning, Waste Heat Recovery”, 1st ETA Conference, Berlin, Germany, Springer.
4. Ibrahim Dincer and Mark A Rosen, “Thermal Energy Storage Systems and Applications”, John Wiley and Sons 2011.
5. Waste Heat Recovery – Technology and Opportunities in US Industry, BCS Incorporated
6. Rolf Kehlhofer, “Combined Cycle Gas and Steam Turbine Power Plants”, PennWell Corporation.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME423T					Exergy Analysis of Thermal Systems					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVE

- To impart detailed study of exergy analysis of thermal components and power cycle

UNIT 1 Review of thermodynamics and basic exergy concepts (10)

Recapitulation of laws of thermodynamics: First law and second law of thermodynamics, Exergy: exergy analysis, exergy of closed system, exergy of matter flow, exergy of thermal energy, exergy of work, exergy of electricity, exergy consumption, Gouy-Stodola relation, Exergy balance, energy and exergy efficiency

UNIT 2 Energy and Exergy assessment method (10)

Energy and exergy assessments of thermal components: heat exchangers, pumps, compressors, fans, throttle valves, turbines; Energy and exergy assessments simple processes: psychrometric processes, sensible cooling, sensible heating, heating and humidification, cooling with humidification, adiabatic mixing of air streams, evaporative cooling, energy and exergy assessments of integrated systems

UNIT 3 Exergy analysis of thermal plants (12)

Industrial cooling and heating systems, Heat pump systems, Gas turbine plant, Cogeneration, multigeneration and integrated energy systems, Energy storage systems, Renewable energy based systems

UNIT 4 Thermo-economic applications of exergy (10)

Linkages between exergy, economics, the environment and sustainability, life cycle assessment: stages of life cycle assessment, exergetic life cycle assessment, levelized cost of energy, capital recovery factor, Case studies of exergy costing in different thermal components

Max : 42 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Recall the concepts of energy, exergy and irreversibility
CO2: Demonstrate the exergy analysis as method and tool for thermal components and power cycle.
CO3: Evaluate the exergy of energy and material flows.
CO4: Utilize the exergy balances for thermodynamic systems, including new/unknown systems.
CO5: Utilize exergy analysis to map exergy transfer and exergy losses in thermal processes.
CO6: Develop the methodology for increasing the energy efficiency of thermal plants through exergy-economic analysis.

TEXT/REFERENCE BOOKS

1. T. J. Kotas, The Exergy Method of Thermal Plant Analysis, Elsevier (2013)
2. Ibrahim Dincer and Marc A. Roshan, Exergy analysis of Heating, Refrigerating and Air-conditioning, Elsevier (2015)
3. Adrian Bejan, George Tsatsaronis, Michael J. Moran, Thermal Design and Optimization, John Wiley & Sons (1995)
4. Michael J. Moran, Availability Analysis: A Guide to Efficient Energy Use, Amer Society of Mechanical (1990)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks	20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks	80 Marks

20ME424T					Solar Photovoltaic Fundamental: Technologies & Application					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- 1. Analyze solar photovoltaic system applications.
- 2. Identify various energy technologies, codes, certifications and their relationship with solar photovoltaic system.
- 3. Apply contemporary energy products and technologies to solar photovoltaic systems and energy conservation.
- 4. Explain the layout and design requirements for solar photovoltaic systems in residential and commercial constructions.
- 5. Compare and contrast solar photovoltaic system materials and methods.

UNIT 1 Solar Energy **(10)**

Introduction: Fossil fuel energy usage and global warming; role of renewable energy in sustainable development; renewable energy sources; global potential for solar electrical energy systems. **Principles of solar radiation** - physics of the sun, solar spectrum, the solar constant, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data

UNIT 2 Solar Photovoltaic System Components **(10)**

PV cell- module-array, PV junctions – Invertors – Cabling, wiring and connection system – Batteries – Charge controller – standalone inverters

UNIT 3 Planning and Design of Grid connected and Standalone photovoltaic systems **(14)**

Grid-connected single phase PV inverter schemes and control, power processing schemes based on single string, multi-string and ac module technologies, types of grid interface, power electronic converters used in single phase PV systems and their operation, transformer less inverters, centralized grid-connected three-phase inverters for large PV installations.

UNIT 4 Installation, troubleshooting and safety **(06)**

Installation and troubleshooting of standalone Solar PV system and Solar PV power plants – Electrical safety – Safety precautions for batteries – Mechanical safety - energy yield and economics of a PV installation

Max : 40 Hrs

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: Analyze solar photovoltaic system energy and building resources.
CO2: Critically assess solar photovoltaic system applications, site evaluation.
CO3: Investigate solar photovoltaic systems and their relationship with energy conservation.
CO4: Compare and contrast solar photovoltaic system energy sources and applications.
CO5: Understanding of the current technology and futuristic applications of Solar PV devices.
CO6: Recognize the need and ability to engage in lifelong learning for further developments in this field.

TEXT/REFERENCE BOOKS

1. Solanki, Chetan Singh. Solar photovoltaics: fundamentals, technologies and applications. PHI Learning Pvt. Ltd., 2015.
2. Solanki, Chetan Singh. Solar photovoltaic technology and systems: a manual for technicians, trainers and engineers. PHI Learning Pvt. Ltd., 2013.
3. Deutsche Gesellschaft für Sonnenenergie (DGS). Planning and installing photovoltaic systems: a guide for installers, architects and engineers. Routledge, 2013
4. Duffie, J.A., Beckman, W.A. and Worek, W.M., 2013. Solar engineering of thermal processes (Vol. 3). New York: Wiley

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from each unit, each carrying 2 marks 20 Marks
Part B/Question: 2 Questions from each unit with internal choice, each carrying 16 marks 80 Marks

20ME425T					Machinery Fault Diagnosis and Signal Processing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand various kinds of maintenance methods applied in industry.
- To study various types of signatures generated from the machinery components.
- To identify, interpret and apply vibration based condition monitoring techniques.
- To systematically analyze the machine learning algorithms for mechanical applications.

UNIT 1 Introduction **10 Hrs.**

Introduction, Types of Maintenance preventive, breakdown etc., Maintenance Strategies, Failure Modes and Effects Criticality Analysis (FMECA),Types of condition monitoring techniques, advantages and disadvantages, Case studies and analysis

UNIT 2 Signal Processing Techniques **12 Hrs.**

Introduction, Machinery signatures, Selection of Transducers and signal conditioning. Analysis Techniques such as time, frequency, combined time frequency methods, FFT, Wavelet etc. Machine failure modes, Measurement location, Case studies.

UNIT 3 Vibration based condition monitoring **11 Hrs.**

Real-Time Image Feature Extraction and Defect/Fault Classification, The Virtual Sensor, Fusion or Integration Technologies, Usage-Pattern Tracking, Vibration severity criteria, Case studies

UNIT 4 Application of Artificial Intelligence Techniques **12 Hrs.**

Introduction, Machine Learning: Supervised, Unsupervised learning and semi supervised learning, advantages and disadvantages, Feature vectors and classification, Linear and Nonlinear classifiers, Feature selection and dimensionality reduction. Case Studies and Analysis using Experimental Data.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1: **Compare** and **classify** various maintenance strategies.

CO2: Interpret and **Analyze** machinery component signatures.

CO3: **Classify** various types of signal processing techniques.

CO4: Identify and **Analyze** suitable condition monitoring technique.

CO5: **Distinguish** and apply various machine learning methods.

CO6: **Demonstrate** the applications of Artificial Intelligence Techniques in mechanical engineering.

TEXT/REFERENCE BOOKS

1. A. R. Mohanty, Machinery Condition Monitoring: Principles and Practices, CRC Press, first edition (2014)
2. R. Isermann, Fault-Diagnosis Applications Model-Based Condition Monitoring: Actuators, Drives, Machinery, Plants, Sensors, and Fault-tolerant Systems, Springer (2011)
3. J. S. Rao, Vibratory Condition Monitoring of Machines, Narosa, first edition (2000)

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A : 4 Questions each carrying 10 Marks 40 Marks

Part B : 4 Questions each carrying 15 Marks 60 Mark

20ME426T					Advanced Metaheuristics Optimization					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	--	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems.
- To define Metaheuristics for specific problems.
- To apply the mathematical results and numerical techniques of Advanced Metaheuristics Optimization to concrete Engineering problems.

UNIT 1 Introduction to General Optimization Problem **10 Hrs.**

General optimization problems, Engineering Applications of Optimization, Statement of an Optimization Problem, Classification of Optimization Problems, Single and multi Variable Optimization

UNIT 2 Introduction to Metaheuristics Optimization **09 Hrs.**

Introduction and Overview of Heuristic and Meta-Heuristic Search, Fitness functions, Local search vs. Meta-heuristic search, Visualization of the Search Landscape, Classification of metaheuristics

UNIT 3 Computational Swarm Intelligence **13 Hrs.**

Genetic algorithm, Simulated annealing, Particle Swarm optimization, Ant Colony optimization, and other Computational Swarm Intelligence algorithm, Hybrid Computational Swarm Intelligence algorithm, Application Computational Swarm Intelligence to mechanical domain problems

UNIT 4 Multi Objective Computational Swarm Intelligence **13 Hrs.**

Non dominated sorting genetic algorithm II (NSGA-II), Multi objective teaching-learning-based optimization, Multi objective Particle Swarm optimization, etc. Application of Multi Objective Computational Swarm Intelligence to mechanical domain problems

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Formulate** the mathematical model of Mechanical Problems.
CO2 - **Demonstrate** engineering and managerial problems.
CO3 - **Classify** the Metaheuristics Optimization.
CO4 - **Solve** single objective optimization problems using Computational Swarm Intelligence.
CO5 - **Solve** multi objective optimization problems using Multi Objective Computational Swarm Intelligence.
CO6 - **Design** and propose new and hybrid optimization algorithms.

TEXT/REFERENCE BOOKS

1. Z. Michalewicz and D. B. Fogel, "How to Solve it: Modern Heuristics", Springer.
2. J. Dreo, P. Siarry, A. Petrowski and E. Taillard , "Metaheuristics for Hard Optimization", Springer..
3. El-Ghazali Talbi, Metaheuristics: From Design to Implementation, Wiley.
4. D. Simon, “Evolutionary Optimization Algorithms”, Wiley.
5. Xin She Yang, Nature-inspired Metaheuristic Algorithms, Luniver Press.
6. S. S. Rao, Engineering optimization: Theory and Practice, New Age publication.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
2 Questions of 5 marks each –no choice	10 Marks
2 Questions of 15 marks each –no choice	30 Marks
3 Questions of 20 marks each –no choice	60 Marks

20ME427T					Micro and Nano Manufacturing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To understand the requirements for micro/nano manufacturing
- To introduce various mechanical micro machining techniques
- To provide basics of various micro/nano finishing processes
- To introduce micro/nano fabrication methods

UNIT 1 **9 Hrs.**

Introduction to Precision engineering, macro milling and micro drilling, Micro-electromechanical systems – merits and applications. Introduction to Bulk micromachining, Surface micromachining- steps, Micro instrumentation – applications, Micro Mechatronics, Nano finishing – finishing operations. Introduction to Nanotechnology. Carbon Nano-tubes – properties and structures, Molecular Logic Gates and Nano level Biosensors - applications

UNIT 2 **11 Hrs.**

Introduction to mechanical micromachining, Micro drilling – process, tools and applications. Micro turning- process, tools and applications, Diamond Micro turning – process, tools and applications. Micro milling and Micro grinding – process, tools and applications. Introduction to Non-conventional micro-nano manufacturing. Process, principle and applications – Abrasive Jet Micro Machining, WAJMM. Micro EDM, Micro WEDM, Micro EBM – Process principle, description and applications. Micro ECM, Micro LBM - Process principle, description and applications

UNIT 3 **10 Hrs.**

Introduction to Micro and Nano Finishing Processes. Magnetorheological Finishing (MRF) processes, Magnetorheological abrasive flow finishing processes (MRAFF) – process principle and applications. Force analysis of MRAFF process, Magnetorheological Jet finishing processes. Working principle and polishing performance of MR Jet Machine. Elastic Emission Machining (EEM) – machine description, applications. Ion Beam Machining (IBM) – principle, mechanism of material removal, applications. Chemical Mechanical Polishing (CMP) – Schematic diagram, principle and applications

UNIT 4 **10 Hrs.**

Introduction to Micro Fabrication: basics, flowchart, basic chip making processes. Introduction to Nanofabrication, Nanofabrication using soft lithography – principle, applications – Examples (Field Effect Transistor, Elastic Stamp). LIGA Process. Laser Micro welding – description and applications, Defects. Electron Beam Micro-welding – description and applications. Introduction to micro and nano measurement, defining the scale, uncertainty. Scanning Electron Microscopy – description, principle. Optical Microscopy – description, application. Scanning Probe Microscopy. Introduction to On-Machine Metrology.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Illustrate** various mechanical micro machining methods
CO2 – **Compare** macro mechanical machining and micro mechanical machining methods
CO3 – **Understand** various micro/nano fabrication techniques
CO4 – **Judge** application of micro and nano finishing
CO5 – **Identify** application of micro fabrication
CO6 – **Compare** different micro and nano measurement methods

TEXT/REFERENCE BOOKS

1. V.K. Jain, Micro-manufacturing Processes CRC Press, 2012
2. Nitaigour Premchand Mahalik, Micro-manufacturing and Nanotechnology, 2006
3. Mark. J. Jackson, Micro-fabrication and Nano-manufacturing – Pulsed water drop micromachining CRC Press, 2006
4. Mark. J. Jackson, Micro and Nano-manufacturing, Springer, 2006.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 8 Questions from all units carrying 2.5 marks each	20 Marks
Part B/Question: 2 Questions from each unit carrying 10 marks	80 Marks

20ME428T					Advanced Materials and Characterizations					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To know modern materials with their applications.
- To develop understanding of importance of characterization of materials.
- To identify the various microstructural features in different alloys.

UNIT 1 Advanced materials **9 Hrs.**

Need, manufacturing and processing, properties, applications. Super alloys, nanostructured alloys, shape memory alloys, micro alloying, nanocomposites, superplastic alloy, SMART materials, nonmetallic- composites, plastics, ceramics. Microstructural evolutions during manufacturing or processing, relation between microstructure and properties, macro, micro and nano scale behavior, chemical components quantitative distribution, crystal orientations and its quantifications, material failure analysis.

UNIT 2 Optical and Electron microscopy **9 Hrs.**

Role of etchant, basic principle, instrumentations, three-dimensional images, specimen preparations, applications. SEM: electron sources, modes of operation, fractography, chemical analysis using energy dispersive analysis, specimen preparations, applications.

UNIT 3 EBSD, XRD and TEM **9 Hrs.**

Crystal lattice structure and orientations, grain size and its boundaries distributions, dislocation densities, texture, specimen preparations, applications. Generation of X-rays, principles of diffraction, X - ray generation, Instrumentation, Types of analysis, Elements of Image Analysis and Quantitative Metallography X-Ray Diffraction. TEM: Basic principles, Thin Film and Replication Techniques, Image Contrast, Bright Field and Dark Field Imaging, applications.

UNIT 4 Thermal, Wear and Corrosion measurements and analysis **9 Hrs.**

Instrumentation, experimental parameters, different types used for analysis, differential thermal analysis, differential scanning calorimetry, applications. Corrosion friction and wear measurements: basic principle, instrumentations, specimen preparation, applications.

36 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1. Evaluate significance on advanced materials and characterizations.

CO2: Distinguish various characterization techniques.

CO3. Compare various materials and their mechanical properties.

C04. Apply fundaments of characterization and develop understanding on microstructure features and their effect on the properties of materials.

CO5: Develop skills of specimen preparations of the various characterization techniques.

C06. Evaluate material performance based on microstructural characteristics of advanced materials.

TEXT/REFERENCE BOOKS

1. W. D. Callister, Materials Science and Engineering: An Introduction, John Wiley & Sons, 2007.
2. ASM Handbook: Materials Characterization, ASM International.
3. Yang Leng: Materials Characterization-Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
Part A/Question: 3 Questions from each unit - each carrying 5 marks	60 Marks
Part B/Question: 1 Question from each unit- each carrying 10 marks	40 Marks

20ME429T					Lubrication					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	6	3	25	50	25	--	--	100

COURSE OBJECTIVES

- Understand the basic concept of friction, wear and lubrication.
- To apply the underlying concepts, methods, and application of lubrication in Tribology.
- To Familiarize with selection, design and testing of rolling element bearings and fluid film bearings.

UNIT 1 LUBRICATION **12 Hrs.**

Fundamentals, Types of Lubrication, Viscosity and its Types of Lubrication, Types of Bearings, Equations of Continuity and Motion, Hydrodynamics of Simple Configuration. Surfaces, Friction and Wear: Topography of Surfaces, Surface features, Surface interaction, Theory of Friction, Sliding and Rolling Friction, Friction properties of metallic and non -metallic materials, Wear, types of wear, Mechanism of wear.

UNIT 2 LUBRICATION THEORY **10 Hrs.**

Lubricants and their physical properties lubricants standards , Lubrication Regimes in Hydrodynamic lubrication, Reynolds Equation, Thermal, inertia and turbulent effects, Elastohydrodynamic (EHD) magneto hydrodynamic lubrication, Hydro static lubrication, Gas lubrication, Solid lubrication.

UNIT 3 DESIGN AND SELECTION OF BEARINGS **13Hrs.**

Design of Fluid Film Bearings: Design and performance analysis of thrust and journal bearings, Lubricant flow rate, Power loss, Heat and temperature of steady and dynamically loaded journal bearings, Hydrostatic Bearing design.
Rolling Element Bearings: Geometry and specifications (ISO standards), Contact stresses, Hertzian stress equation, Load rating Bearing life capacity and variable loads, Rolling Bearings Failures.

UNIT 4 TRIBO MEASUREMENT AND INSTRUMENTATION **10 Hrs.**

Surface Topography measurements, Electron microscope and friction and wear measurements, Laser method, Instrumentation, International standards, Bearings performance measurements, Bearing vibration measurement.

Max. 45 Hrs.

COURSE OUTCOMES: On completion of the course, student will be able to

CO1: **Build** an understanding on the fundamentals and principles of Lubrication and tribology.
CO2: **Analyze and apply** the concept of friction, wear and lubrication in an industrial context.
CO3: **Analyze** the various parameter that influence the performance of tribo-system.
CO4: **Develop** an ability to mathematically model and evaluate the performance of a tribo-system.
CO5: **Apply** principles of applied lubrication in design and selection of bearing system.
CO6: **Understand** the working principle of different tribo-testing apparatus/instrument used in industry.

TEXT/REFERENCE BOOKS

1. Khonsari, M.M. and Booser, E.R., 2017. Applied tribology: bearing design and lubrication. John Wiley & Sons.
2. Bhushan, B., 2013. Introduction to tribology. John Wiley & Sons.
3. Harnoy, A., 2002. Bearing design in machinery: engineering tribology and lubrication. CRC press.
4. Majumdar, B.C., 2008. Introduction to tribology of bearings. S. Chand Publishing.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100	**Exam Duration: 3 Hrs**
5 questions of 2 marks each - No choice	10 Marks
4 questions of 5 marks each - No choice	20 Marks
5 questions of 10 marks each and one question of 20 Marks - No choice	70 Marks

20ME430T					Elements of Mechatronics System Design					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To get the basic understanding of Mechatronic systems and its application.
- To have knowledge of various sensors and transducers.
- To evaluate signal conditioning through operational amplifiers and gain the knowledge of digital signals and digital logics.
- To understand the working of microprocessor and microcontroller systems and demonstrate the ability to interface hardware control boards (ARDUINO) with mechanical systems.
- To obtain the mathematical modelling and dynamic response of mechanical, electrical, fluid and thermal systems.
- To utilize the knowledge of system transfer function and frequency response to design closed loop controls.

UNIT 1 Introduction to mechatronics **8 Hrs.**

Introduction to mechatronics systems, Need and classification of mechatronics system, measurement and control systems.

UNIT 2 Sensors, transducers and signal conditioning **12 Hrs.**

Sensors and transducers - performance terminologies. Displacement, position, velocity, force, pressure, flow, temperature and light sensors. Signal conditioning, Operational amplifier. Digital signals, ADC, DAC. Digital logic, logic gates and its application. Actuation systems- Pneumatic, mechanical and electrical actuation systems. Types of Stepper and Servo motors – Construction – Working Principle – Advantages and Disadvantages.

UNIT 3 Microprocessor ad microcontroller systems **8 Hrs.**

Microprocessor and microcontroller systems. Buses. Architecture of 8085. Programming of developmental board (ARDUINO). Introduction to programmable logic controller.

UNIT 4 System modelling **12 Hrs.**

Mathematical modelling and dynamic response of mechanical, electrical, fluid and thermal systems. Transfer functions of first and second order systems. Root locus and frequency response of dynamical systems. Closed loop control. Proportional, Integral and derivative (PI, PD and PID) controls. Case studies of Mechatronics systems - Pick and place Robot, Engine Management system, Automatic car park barrier.

Max. 40 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 - **Understand** the basics of mechatronic systems.

CO2 - **Classify** the various sensors and transducers based on the needs of mechatronic systems.

CO3 - **Utilize** the signal conditioning through Op-Amps and **Apply** the digital logics to the digital signals.

CO4 - **Illustrate** the microprocessor and microcontroller systems and **Demonstrate** the programming.

CO5 - **Obtain** the mathematical modelling and dynamic response of mechanical, electrical & thermal systems.

CO6 - **Develop** system transfer function and frequency response to design closed loop controls.

TEXT/REFERENCE BOOKS

1. William Bolton, "Mechatronics - Electronic control systems in mechanical and Electrical Engineering", Pearson Education Limited, 6th edition, 2008
2. The Mechatronics handbook, Robert Bishop, CRC PRESS 2002.

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 10 Questions from unit I, II and III 25 Marks

Part B/Question: 15 Questions from Unit IV 75 Mark

20ME431T					Automobile Engineering					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	0	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To comprehend the function of various components of a modern-day automobile.
- To understand the significance of automotive parameters on the performance of the automobile.
- To outline the current standard norms and modern technologies in the domain of automobile engineering.

UNIT 1 **08 Hrs.**

Introduction to Automobile and its Performance: Automobile parts, assembly of vehicle, power required for acceleration, stability of a vehicle on a slope, dynamics of a vehicle running on banked track, stability of a vehicle taking a turn.
Chassis, Frame & Body: Types, comparison, Comparison of front and rear mounting of engine, aerodynamic considerations in body profiling, Ergonomic considerations, defects in frames and body.

UNIT 2 **14 Hrs.**

Clutch: Constructional features and working of different types of clutch (like single plate, multi plate, cone, semi− centrifugal, fully, centrifugal, wet etc.) used in automobiles, calculation of surface area and number of driving and driven plates, fluid coupling.
Gear Box: Functions of gearbox, need of gear box, gears & gear ratios, principle of gearing, types of gear boxes, manual gearboxes.
Automatic Transmission: Basic devices used in automatic transmission, principle of epicyclic gearing, torque converter, free wheel clutch, over speed drive and its working, semi, fully automatic transmission, continuously variable transmission (CVT).
Propeller Shaft: Propeller shafts and their types, fluid drive and fluid flywheel, universal joints, hotch-kiss drive, torque tube drive.
Differential: Principle of the differential, locking differential, limited slip differential
Final Drive and Rear Axle: Final drives and its types, hypoid type final drive, rear axle, rear axle drives, rear axle shaft supporting, rear axle casing, axle breather, oil retention

UNIT 3 **12 Hrs.**

Front Axle: Types, construction, components and their functions
Suspension System: Principle, type of suspension system, conventional and independent front and rear axle, spring, rubber and air suspensions, automatic, hydro suspension system, shock absorbers.
Steering System: Steering layout, types of steering gears, steering linkages, steering mechanism, steering geometry, measurement and adjustment of various steering system layouts, steering ratio, under steering and over steering, power assisted steering, wheel alignment
Brakes: Principle, braking distance, braking efficiency, weight transfer, wheel skidding, principle and working of various types of brakes (like drum, disc, mechanical, girling, hydraulic etc.) power assisted brakes, hand brake, anti−lock brake systems (ABS).
Battery: Construction, working, methods of rating, faults, charging methods.
Lighting system: Wiring system, head lights, aiming of head lights, indicating lights.
Accessories like direction indicators, hazard flashes, horn, speedometer, tachometer, wind screen wiper, wind screen washer, central locking system, power windows, and vehicle tracking system. Safety provisions like air bags, safety belts.

UNIT 4 **11 Hrs.**

Regulation and Standardization of Vehicles: Motor vehicle act, registration of motor vehicles, driving license, control of traffic, insurance against third party, traffic signs, central motor vehicle rules, vehicle safety standards and regulations, vehicle Pollution Norms
Modern Vehicles: Construction and operational features of four wheelers available in Indian market, Vehicle Management Systems, ESP, Hill Assist, ACC, EBD, Lane Assist, Smart Features. Introduction to electric vehicles & hybrid vehicles. Connected Cars and IOT.

Max. 45 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Analyse the performance characteristics of an Automobile and the factors affecting it.
CO2 – Analyse the transmission system of an Automobile.
CO3 – Explain the working of suspension and steering systems in an Automobile.
CO4 – Compare the relative working and performance of various auxiliaries and sub-systems of an Automobile.
CO5 – Summarize the function of electrical and safety systems in an Automobile.
CO6 – Identify the standard norms and modern technologies in the domain of Automobile Engineering.

TEXT/REFERENCE BOOKS

1. Automobile Engineering Vol− I & II by Dr. Kirpal Singh, Standard Pub.& Dist.
2. Automobile Engineering Vol− I & II by Dr. K.M. Gupta, Umesh Pub.
3. Automobile Technology by Dr. N.K. Giri, Khanna Pub.
4. Automotive Mechanics by W. Crouse, Tata Mc Graw Hill

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**
10 questions 10 marks each 100 Marks

20ME432T					Advance Manufacturing Process					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	-	-	3	3	25	50	25	--	--	100

COURSE OBJECTIVES

- To introduce various non-conventional/advanced machining techniques
- To introduce advanced welding techniques
- To explain the application of micro wave processing in manufacturing domain
- To provide basic understanding on advanced casting processes

UNIT 1: Advanced Material Removal Processes (Mechanical): 10 Hrs.

Need for advanced material removal processes, Classification of advanced machining/material Removal processes, considerations in process selection and applications-Ultrasonic Machining Process–Mechanism of material removal, ultrasonic Machine and its process Parameters, Modeling of MRR in USM, economic considerations-Abrasive Flow Machining- Principle, AFM technology, process parameters in AFM, Ultrasonic flow polishing, Orbital AFM, Magneto abrasive flow machining, Centrifugal force assisted AFM-Abrasive jet machining–Principle, Components and process parameters, modeling of MRR in AJM for brittle material-Water jet and abrasive Water Jet Machining–Process principles, modeling of mixing process, modeling of MRR in WJM & AWJM

UNIT 2: Advanced Material Removal Processes (Thermal, Electrochemical and Chemical): 12 Hrs.

Electrical Discharge Machining – EDM principle, Mechanism of material removal in EDM-Die sink EDM, wire cut EDM, Powder mixed EDM, overcut, ovality, taper ratio, taper angle in EDM, modeling of MRR in EDM, Micro-EDM (Introduction)-Laser Beam Machining–Principle of Laser, solid state lasers, gas state lasers, Classification of laser beams, Types of laser, Mechanism of Material Removal using laser beam, Process parameters, modeling of MRR in LBM-Electron beam machining–removal mechanism-Electrochemical Machining–Mechanism of Material Removal in ECM, The Subsystems of Electro-Chemical Machining, ECM process parameters, MRR of alloy in ECM, Dynamics of ECM (no feed condition and with feed condition. Economic aspects of ECM-Chemical machining: Important steps in chemical machining, etchants in chemical machining, Ultrasonic-Assisted Electrochemical Machining–Abrasive Electro-discharge Grinding, EDM with Ultrasonic Assistance-Electrostream drilling.

UNIT 3: Advanced Welding Processes 10 Hrs.

Cold metal transfer welding – Working principle, CMT pulse, Advanced CMT, application-Pulse arc welding – Pulse gas tungsten arc welding and pulse gas metal arc welding (P-GMAW)-Ultrasonic welding – Introduction of different types of ultrasonic welding (Ultrasonic seam welding, ultrasonic torsion welding, Ring welding, line welding), application-Electron Beam Welding – EBW Equipment, process parameters, process capabilities, advantages, limitation, application-Hybrid welding processes – Hybrid Laser Arc Welding, TIG-MIG hybrid welding, hybrid friction stir welding

UNIT 4: Micro wave and Advanced Casting Processes 07 Hrs.

Microwave Processing of Materials – The electromagnetic spectrum, Conventional and microwave heating, Polarization and Conduction, Unique benefits and distinctive features of Microwave Processing, Microwave Applications, Sintering using microwaves, Microwave Joining of non-metallic materials, Microwave coating and cladding-Advances in casting processes – Evaporative Pattern Casting, Hybrid Evaporative Pattern Casting Process, Vacuum Sealed Moulding Process, Ceramic Shell Investment Casting Process

Max. 39 Hrs.

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – **Understand** various non-conventional/advanced manufacturing techniques
CO2 – **Judge** the energy source responsible for removing material in advanced machining techniques
CO3 – **Analyse** the influence of parameters on various advanced machining performance
CO4 – **Select** appropriate machining techniques for a given material
CO5 – **Understand** advanced welding methods
CO6 – **Application** of micro wave processing in manufacturing and **Understand** advanced casting processes

TEXT/REFERENCE BOOKS

1. Hassan El6Hofy, Advanced machining processes, Non6traditional and hybrid machining processes, Tata Mcgraw Hill.
2. Mehta K. (2017) Advanced Joining and Welding Techniques: An Overview. In: Gupta K. (eds) Advanced Manufacturing Technologies. Materials Forming, Machining and Tribology. Springer publisher.
3. V. K. Jain, Advanced Machining Processes, Allied Publishers Mumbai.
4. Serope Kalpakjian, Manufacturing Processes for Engineering Materials, Pearson India

END SEMESTER EXAMINATION QUESTION PAPER PATTERN

Max. Marks: 100 **Exam Duration: 3 Hrs**

Part A/Question: 8 Questions covering all Units, carrying 2.5 marks 20 Marks
Part B/Question: 2 Questions from each unit each carrying 10 marks 80 Marks

20ME410T					Seminar and Technical Writing					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
0	0	4	2	04	-	-	-	-	-	50

COURSE OBJECTIVES

- Students can gain skills of group interaction, skills of integrative discussion, critical evaluation and exploring and mining a text through seminar.
- Students can develop the technical writing skill

Seminar

Each student must present any technical topic for 15 mins followed by an evaluation by a teacher for 10 minutes using evaluation criteria. All other students must attend and can give suggestions. Each student must give minimum two presentations per semester.

Technical writing

1	Definitions, structure and types of reports	4 Hrs
2	Importance of references, glossary and bibliography. How to write and insert them in reports.	6 Hrs
3	Use and types of charts and illustrations in report writing	6 Hrs
4	Various report writing techniques	6 Hrs
5	Computer aided report writing practices	4 Hrs
		26 Hrs

COURSE OUTCOMES

On outcome of the course would be as follows:
CO-1: Shy or reserved students find voice.
CO-2: Students are highly motivated to research and prepare for discussion
CO-3: Group sharing provides a more in-depth understanding of the text
CO-4: Students develop the skills for report writing.
CO-5: Students learn the standard process to write a publication quality report or research article
CO-6: Familiarization of various software tools for report writing

References:

1. Malcolm Goodale, Professional Presentations, Cambridge University Press (2009)
2. MK Rampal and S L Gupta, Project report writing, Galgotia Publishing Company, New Delhi (2010)

END SEMESTER EXAMINATION PATTERN

Max. Marks: 50

Part A: Writing skill 25 marks
Part B: Presentation 25 Marks

Course Structure of B.Tech. in Mechanical Engineering

COURSE STRUCTURE FOR B.TECH. FOURTH YEAR (Mechanical Engineering)

SEMESTER VIII (Subjects)				B.TECH. FOURTH YEAR (Mechanical Engineering)											
Sr. No.	Category Code	Course Code	Course Name	Teaching Scheme					Exam Scheme						
				L	T	P	C	Hrs/wk	Theory			Practical		Total Marks
									CE	MS	ES	CE	ES	
1	Project	20TP420	Major Project/ Comprehensive Project	-	-	-	13	-	-	-	-	50	50	100
			Total	**-**	**-**	**-**	13	-						

CE = Continuous Evaluation MS = Mid Semester Exam ES = End Semester Exam

Pandit Deendayal Energy University **School of Technology**

20TP420					Major Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	-	13	-	-	-	-	50	50	100

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Undertake problem identification, formulation and solution by considering ethical responsibility

CO2 – Demonstrate a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – Formulate and develop a hardware/software based prototype model

CO4 – Achieve skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – Identify and apply appropriate steps to solve problems they have met during implementation of their project

CO6 – Design engineering solutions to complex problems utilizing as system approach

Pandit Deendayal Energy University **School of Technology**

20MEXXP					Comprehensive Project					
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
-	-	-	13	-	-	-	-	50	50	100

COURSE OUTCOMES

On completion of the course, student will be able to

CO1 – Undertake problem identification, formulation and solution by considering ethical responsibility

CO2 – Demonstrate a sound technical knowledge of their selected project topic and function as a member of a team in the solution of engineering problems

CO3 – Formulate and develop a hardware/software based prototype model

CO4 – Achieve skill to write technical documents and deliver oral presentation before an evaluation committee which in turn shall develop the communication skills

CO5 – Identify and apply appropriate steps to solve problems they have met during implementation of their project

CO6 – Design engineering solutions to complex problems utilizing as system approach