C.V.RAMAN GLOBAL UNIVERSITY

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE & SYLLABUS (B.TECH)

ADMISSION BATCH
2020-24

B.TECH. PROGRAM STRUCTURE FOR BATCH 2020-24
(MECHANICAL ENGINEERING)

SEMESTER-III

Sl. No.	Subject Code	Subject	Category	Credits				Hour/Week			
				L	P	T	Course Credits	L	P	T	Course Hour
1	MHE 23311	Engineering Thermodynamics	Program Core-1	3	2	0	5	3	3	1	7
2	MHE 23313	Mechanics of Solids	Program Core-2	3	2	0	5	3	3	0	6
3	MHE 21215	Engineering Metallurgy	ES (Engineering Science)	3	0	0	3	3	0	0	3
4	MTH21104	Mathematics -III	BS (Basic Science)	3	0	0	3	3	0	1	4
5	UGE 21101	Living Biology and Environmental Science	Theory – MC (Mandatory Course) (BS) (Basic Science)	2	0	0	2	2	0	0	2
6	UGE 21102	Emerging Materials and its applications.									
7	HSS21001	EEC (Economics for Engineers)	HSM (Humanities Social Sciences and Management)	2	0	0	2	2	0	0	2
8		Skill Development Elective1	SDE 1 (Skill Development Elective)	0	2	0	2	0	3	0	3
9		Carrier Development Training (CDT-1)	MC (Mandatory Course)	0	0	0	0	2	0	0	2
		Total		**16**	**6**	**0**	**22**	16	9	2	29

B.TECH. PROGRAM STRUCTURE FOR BATCH 2020-24
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SEMESTER-IV

Sl. No.	Subject Code	Subject	Category	Credits				Hour/Week			
				L	P	T	Course Credits	L	P	T	Course Hour
1.	MHE 23310	Basic Manufacturing Process	Program Core-3	3	2	0	**5**	3	3	1	7
2.	MHE 23314	Fluid Mechanics & Hydraulic Machines	Program Core-4	3	2	0	**5**	3	3	0	6
3.	MHE 21316	Metrology Quality Control and Reliability	Program Core-5	3	0	0	**3**	3	0	1	4
4.	MHE 23318	Mechanics of Machines	Program Core-6	3	2	0	**5**	3	3	0	6
5.	UGE 21101	Living Biology and Environmental Science	Theory – MC (Mandatory Course) (BS) (Basic Science)	2	0	0	**2**	2	0	0	2
6.	UGE 21102	Emerging Materials and its applications.									
7.		Skill Development Elective2	SDE 2 (Skill Development Elective)	0	2	0	**2**	0	3	0	3
8.		Carrier Development Training (CDT-2)	MC (Mandatory Course)	0	0	0	0	2	0	0	2
		Total		**14**	**8**	**0**	**22**	14	12	2	30

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SEMESTER-V

Sl. No.	Subject Code	Subject	Category	Credits				Hour/Week			
				L	P	T	Course Credits	L	P	T	Course Hour
1.	MHE 21317	Machine Design	Program Core -7	3	0	0	**3**	3	0	1	4
2.	MHE 23319	Heat Transfer	Program Core - 8	3	2	0	**5**	3	3	1	7
3.	MHE 23320	Metal Cutting- Theory & Practice	Program Core - 9	3	2	0	**5**	3	3	0	6
4.		University General Elective-2	UGE 2 (University General Elective)	1	0	0	1	1	0	0	1
5.		Skill Development Elective 3	SDE 3 (Skill Development Elective)	0	2	0	2	0	3	0	3
6.		Carrier Development Training (CDT-3)	MC (Mandatory Course)	0	0	0	0	2	0	0	2
7.		Program Elective1	Program Elective 1	3	2	0	**5**	3	3	0	6
		Total		**13**	**8**	**0**	**21**	**13**	**12**	**2**	**29**

Program Elective1	
MHE 23411	Advanced Manufacturing Processes
MHE 23413	Advanced Mechanics of Solids
MHE 23415	Internal Combustion Engines & GT
MHE 23441	Power Plant Engineering
MHE 21437	Material Characterization Techniques
MHE 23439	Industrial Operations Research

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SEMESTER-VI

Sl. No.	Subject Code	Subject	Category	Credits				Hour/Week			
				L	P	T	Course Credits	L	P	T	Course Hour
1.	MHE 23322	Refrigeration & Air Conditioning	Program Core10	3	2	0	5	3	3	1	7
2.	MHE 23324	Mechanical Vibration	Program Core11	3	2	0	5	3	3	1	7
3.	MHE 21320	Introduction to Automation System	Program Core12	3	0	0	3	3	0	1	4
4.		University General Elective-3	UGE 3 (University General Elective)	1	0	0	1	1	0	0	1
5.		Skill Development Elective 4	SDE 4 (Skill Development Elective)	0	2	0	2	0	3	0	3
6.	MHE 22328	Technical Presentation on Science & Technology Advencement - Assessment and Review (STAAR)	PC (Program Core)	0	1	0	1	0	2	0	2
7.		Carrier Development Training (CDT-1)	MC (Mandatory Course)	0	0	0	0	2	0	0	2
8.		Open Elective	Open Elective 1 (subject is provided to other dept. except ME)	3	0	0	3	3	0	0	3
		Total		**13**	**7**	**0**	**20**	**15**	**11**	**3**	**29**

Open Elective 1	
MHE 21510	Intellectual Property Rights
MHE 21512	Value Engineering
MHE 21514	Vehicle Dynamics
MHE 21516	Total Quality Management

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SEMESTER-VII

Sl. No.	Subject Code	Subject	Category	Credits				Hour/Week			
				L	P	T	Course Credits	L	P	T	Course Hour
1.	MHE 22323	Industrial Training	PC (Program Core)	0	1	0	1	0	2	0	2
2.	MHE 22611	Project-I	MP (Major Project)	0	3	0	3	0	6	0	6
3.											
4.		Program Elective	Program Elective 2	3	2	0	5	3	3	0	6
5.		Open Elective	Open Elective 2 (subject is provided to other dept. except ME)	3	0	0	3	3	0	0	3
6.		Open Elective	Open Elective 3 (subject is provided to other dept. except ME)	3	0	0	3	3	0	0	3
		Total		**9**	**6**	**0**	**15**	**9**	**11**	**0**	**20**

Program Elective 2		**Open Elective 2**		**Open Elective 3**	
MHE 23410	Gas Dynamics & Propulsion	MHE 21511	Introduction to Robotics	MHE 21521	Fundamentals of Mechatronics
MHE 23419	Additive Manufacturing	MHE 21513	Introduction to Microfluidics	MHE 21523	Engineering Biomaterials
MHE 23421	Finite Element Analysis in Engineering	MHE 21515	Renewable Energy Resources	MHE 21525	Introduction to CFD
MHE 23423	Computer Integrated Manufacturing	MHE 21517	Solar Energy Technologies	MHE 21527	Finite Element Methods
MHE 23425	Introduction to Cryogenic Engineering	MHE 21519	Industrial Engineering and Management	MHE 21529	Optimization Engineering
MHE 23427	Product Design and Manufacturing				
MHE 23429	Introduction to Mechatronics				
MHE 23431	Design of HVAC Systems				
MHE 23422	Welding Technology				
MHE 23435	Robotics and Robot Applications				

B.TECH. PROGRAM STRUCTURE FOR BATCH 2020-24
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SEMESTER-VIII

Sl. No.	Subject Code	Subject	Category	Credits				Hour/Week			
				L	P	T	Course Credits	L	P	T	Course Hour
1.	MHE 22612	Project linked Research Paper	PC (Program Core)	0	2	0	2	0	3	0	3
2.	MHE 22614	Project-II	MP (Major Project)	0	12	0	12	0	24	0	24
		Total		**0**	**14**	**0**	**14**	0	27	0	27

Mechanical Engineering Department

Subject Name: Engineering Thermodynamics (L:T:P-3:1:3)

Regulation Year: 2020-24

Course Code: MHE 23311 **Credit: 5**

Course Category: Program Core **Contact hours: 40**

Recommended Pre-requisite: Basic Thermodynamics

COURSE OUTCOMES:After going through this course the student will be able to

CO1: To understand fundamental concepts of Unsteady Flow, Entropy Generation and Property relations.

CO2: To understand Reversible work, Exergy balance and Second Law Efficiency applied to various real life applications

CO3: To understand the modification of basic Rankine vapor power cycle for increment in the cycle thermal efficiency by use of reheating and regeneration.

CO4: To explain the working principle of different types of gas compressors and their applications in engineering industry.

CO5: To analyse Brayton cycle; Brayton cycle with regeneration; and Brayton cycle with intercooling, reheating, and regeneration

Course Details:

Unit1: **(10Hrs.)**

Unsteady Flow

First law analysis of unsteady flow control volumes: Variable flow processes, Analysis of Variable Flow Process (System Technique and Control Volume Technique), Discharging and Charging a Tank.

Entropy Generation

Review of Second Law of Thermodynamics, Entropy generation in a closed system and in an open system, Problems based on Entropy generation

Property relations

General Thermodynamic property relations: The Maxwell relations, The Clapeyron equation, The TdS relations, Isothermal compressibility and volume expansivity, The Joule-Thomson coefficient.

Unit2: **(10Hrs.)**

Availability and Irreversibility

Reversible work: Maximum work in a Reversible Process, Reversible Work by an Open System exchanging heat only with the surrounding, Reversible Work in a

Steady Flow Process and Closed System. Availability and Irreversibility: Availability, Availability in a Steady Flow Process and Non Flow Process, Exergy Balance, Second Law Efficiency, Law of degradation of Energy.

Unit3: **(6Hrs.)**

Vapour Power Cycles

The Carnot vapor cycle and its limitations, The Rankine cycle, Means of increasing the Rankine cycle efficiency, the reheat cycle, the regenerative feed heating cycle, the binary vapor cycle, the gas-vapor coupled cycles, Cogeneration (Back pressure and Pass-out turbines), Efficiencies in Steam Power Plant

Unit4: **(6Hrs.)**

Gas Turbines

Introduction, Open and closed cycle gas turbines, Brayton cycles, The Brayton cycle with non-isentropic flow in compressors and turbines, The Brayton cycle with regeneration, reheating and intercooling.

Air Craft Propulsion

Analysis of Turbo Jet, Turbo Prop, Turbo fan, Free shaft Turbine, Analysis of Ram jet engines.

Unit5: **(08Hrs.)**

Reciprocating Air Compressors

Introduction, Use of compressed air, Classification of compressors, The reciprocating cycle neglecting and considering clearance volume, Volumetric efficiency and its effect on compressor performance, Limitations of single stage compression, Constructional details of single and multistage compressors, Multistage compression and intercooling, Optimum intercooler pressure, theoretical and actual indicator diagram, Air motors.

Axial Flow & Centrifugal Compressor

Basic construction and working of centrifugal and axial flow compressor

Text Books:

T1: Engineering Thermodynamics, P. K. Nag, TMH, 5th Edition, 2013.

T2: Thermodynamics - An Engineering Approach, Y Cengel and Boles, TMH, 7th Edition, 2011

T3: Turbines, Compressors and Fans, S M Yahya, TMH, 4th Edition, 2010

Reference Books:

R1. Fundamentals of Thermodynamics, Sonntag, Borgnakke, Van Wylen, John Wiley & Sons, 7th Edition, 2009.

R2. Fundamentals of Engineering Thermodynamics, E. Rathakrishnan, PHI, 2nd Edition, 2005.

R3. Engineering Thermodynamics, M.Achyuthan, PHI, 2nd Edition, 2009.

R4. Thermal Engineering, P.L.Ballaney, Khanna Publishers,5th Edition, 2010.

R5. Thermal Engineering, Mahesh M Rathore, TMH,2010.

R6. Steam Tables in SI Units, K KRamalingam, Scitech, 1st Edition, 2009.

R7. Gas Turbine, V.Ganeshan, TMH, 3rd Edition, 2010.

Open Sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering/
- http://www.myopencourses.com/discipline/mechanical-engineering

ExperimentDetails: **Weightage**

Experiment 1: Problem-solving on Unsteady flow.

Experiment 2: Problem-solving on Entropy Generation.

Experiment 3: Problem-solving on Entropy Generation.

Experiment 4: Problem-solving on Availability & Irreversibility.

Experiment 5: Problem-solving on Availability & Irreversibility.

Experiment 6: Problem-solving on Vapour Power Cycle.

Experiment 7: Problem-solving on Vapour Power Cycle.

Experiment 8: Problem-solving on Gas Turbines.

Experiment 9: To determine the Volumetric Efficiency of a two-stage air compressor.

Experiment 10: To determine the Isothermal Efficiency of a two-stage air compressor.

Open Sources/Virtual lab: Nil

Subject Name: Mechanics of Solids (L:T:P-3:0:3)

Regulation Year: 2020-24

Course Code:MHE 23313 **Credit: 5**

Course Category: Program Core **Contact hours: 40**

Recommended Pre-requisite: Engineering Mechanics

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Concepts of stress, strain, strain energy and analyze axially loaded members.

CO2: Analysis of stresses, strains and deflections produced in bending of beams.

CO3: Analysis of stresses and strains produced in torsion of circular shafts and calculation of stresses produced in close-coiled helical spring

CO4: Calculation of principal stresses and principal strains in plane strain and plane stress conditions and the application of it to combined bending and twisting problems

CO5: Calculation of stresses developed in thin cylindrical and spherical pressure vessels and Euler's critical load of long columns

Course Details:

Unit 1: **(06 Hrs.)**

Concepts of Stress and Strain

Unit 1.1: Load, Stress, Strain, Shear stress, Complimentary shear stress, Shear strain, Hooke's law, elastic constants and their relationship, Principle of St.Venant, Principle of Superposition, Working Stress, Factor of safety. Analysis of Axially Loaded Members: Deformation of simple and composite bars in tension and compression, thermal stresses in composite bars, Statically indeterminate problems

Unit 1.2: Strain energy in tension and compression, Resilience, Impact loads

Unit 2: **(13 Hrs.)**

Analysis of Simple Bending of Beams

Unit 2.1: Shear Force and Bending Moment for Simple Beams: Types of support and Types of load. Support reactions, Shear force and bending moment. Relationship between bending moment and shear force, Shear Force and Bending Moment diagrams, Point of inflection

Simple Bending of Beams: Theory of simple bending of initially straight beams, bending stresses, Section Modulus, Flexural rigidity, Shear stresses in bending, Distribution of normal and shear stress, Analysis of Composite beams.

Deflection of Beams: Differential equation of the elastic curve, Slope and deflection of beams by integration method, Macaulay method and area - moment method

Unit 2.2: Using singularity functions to determine shear force and bending moment in a beam

Unit 3: **(08 Hrs.)**

Torsion of Shafts and Close-Coiled Helical Spring

Unit 3.1: Torsion in solid and hollow circular shafts, Power transmitted by a shaft, Comparison of solid and hollow shaft by strength and weight

Close-Coiled helical springs: Stresses developed in a spring, Deflection produced in a spring, Strain energy stored in a spring, Springs in series and parallel

Unit 3.2: Torsional rigidity, Shafts in series and parallel.

Unit 4: (08 Hrs.)

Concepts of Principal Stress and Principal Strain

Unit 4.1: Stress at a point, Stresses on inclined planes, Plane stress, Principal stresses, Principal planes, Maximum shearing stress, Maximum shearing plane, Mohr's circle for plane stress, Stresses due to combined bending and torsion, Strength of shafts in combined bending and twisting.

Plane strain, Mohr's circle for strain, Principal strains and principal axes of strain, strain rosette, Calculation of principal stresses from principal strains, Theories of failure.

Unit 4.2: Stresses due to combined bending and torsion, Strength of shafts in combined bending and twisting, Graphical representation of theories of failure.

Unit 5: (05 Hrs.)

Analysis of Thin Pressure Vessels and Columns

Unit 5.1: Stresses in thin cylindrical pressure vessel, thin spherical pressure vessel under internal pressure, Changes in dimensions of a pressure vessel.

Long column and short column, Euler's critical load for different end conditions, Slenderness ratio.

Unit 5.2: Wire winding of thin cylindrical pressure vessel.

Text Books:

T1. "Mechanics of Materials", Ferdinand P. Beer, E. Russell Johnston Jr., Johnston T. DeWolf, and David F. Mazurek, Tata Mcgraw Hill Education Private Limited, Fifth Edition, 2011.

T2. "Strength of Materials", S. Ramamrutham and R. Narayanan, Dhanpat Rai Publishing Company (P) Limited, Seventeenth Edition, 2011.

T3. "Strength of Materials", R. Subramanian, Oxford University Press, Second Edition, 2010.

Reference Books:

R1. "Strength of Materials", G.H. Ryder, Macmillan Publishers India Limited, Third Edition, 2002.

R2. "Engineering Mechanics of Solids", Egor P. Popov, Pearson, Second Edition, 2006.

R3. "Strength of Materials", Dr. Sadhu Singh, Khanna Publishers, Eleventh Edition, 2014.

R4. "Mechanics of Materials", R.C Hibbeler, Printice Hall, Ninth Edition, 2013.

R5. "Strength of Materials", S.S Ratan, Tata Mcgraw Hill Education Private Limited, Second Edition, 2008.

Open sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering/
- http://www.myopencourses.com/discipline/mechanical-engineering

EXPERIMENT DETAILS: **WEIGHTAGE**

Experiment 1: Problem-solving session on Stress and Strain.

Experiment 2: Problem-solving session on Stress and Strain.

Experiment 3: Problem-solving session on Simple Bending of Beams.

Experiment 4: Problem-solving session on Simple Bending of Beams.

Experiment 5: Problem-solving session on Torsion of Shafts.

Experiment 6: Problem-solving session on Principal Stresses.

Experiment 7: Problem-solving session on Principal Stresses.

Experiment 8: Problem-solving session on Principal Strains.

Experiment 9: Problem-solving session on Principal Strains.

Experiment 10: Problem-solving session on Thin Pressure Vessels.

Experiment 11: Problem-solving session on Columns.

Department of Mechanical Engineering

Subject Name: Engineering Metallurgy (L:P:T-3:0:0)

Regulation Year: 2020-2024

Course Code: **MHE 21215** **Credit: 3**

Course Category: **ES** **Contact hours: 42 Hrs**

Recommended Pre-requisite:

- **Material Science**

COURSE OUTCOMES:

CO 1: Understand the importance of material science and deformation in different crystals

CO 2: Aquire knowledge about different testing methods for materials

CO 3: Aquire knowledge about different types of fracture and its analysis

CO 4: Aquire knowledge about the phase transformation of material and iron- iron carbide diagram

CO 5: Aquire knowledge about different heat treatment processes and their effect on properties of materials

Course Details:

Unit1: Introduction to material Science and testing methods (10 Hrs.)

Introduction, (Why study Material science, Classification of Materials, Structures and their property co-relationship in relation to engineering materials.) Single Crystal, Polycrystalline materials, Plastic Deformation of single crystals and polycrystalline materials, Dislocations, Theory of work hardening, Numericals based on theory of plastic deformation.

Unit2: Destructive and Non destructive Testing (10 Hrs.)

Engineering Stress Strain Curve, True stress strain curve, Numerical based on tension test, Hardness test (Brinell, Vickers, Rockwell, knoop) Toughness Test (Impact- Charpy and Izod), compression test, Fatigue, Creep (mechanism of creep), Introduction to Non Destructive Testing Methods

Unit 3: Fracture and Failure Analysis (6 Hrs.)

Ductile fracture, Brittle fractures, Ductile to Brittle transition, Oxidation (mechanism), Corrosion (principle), Methods of protection against fractures.

Unit4: Phase Diagram (8 Hrs.)

Phase rule, Unary, Binary Phase Diagrams, micro-structural changes during cooling, Typical phase diagrams, Invariant reactions, Lever Rule

Introduction, Iron carbon diagram, Significant Temperatures, Definitions of structures, Carbon solubility in Iron, Slow cooling of steel, Classification of steels

Unit 5: Heat Treatment of Steels **(8 Hrs.)**

Introduction, Full Annealing, Normalizing, Hardening, Tempering, Isothermal transformation Diagram for eutectic steel, Products of Austenite, Quenching, Hardenability, Austempering, Jominy End quench Test, Carburising, heat treatment after carburising, Nitriding, Carbonitriding, Flame hardening and Induction hardening.

TextBooks:

T1: Material Science and Engineering", V Raghavan, Prentice Hall of India; New Delhi, 5th Edition, 2004

T2: A Textbook of Material Science & Engineering by Er R. K. Rajput

T3: Materials Science and Engineering by Anish Upadhyaya, G. S. Upadhyaya

Reference Books:

R1. Material Science by Amit Kakani and S. L. Kakani

R2. Callister's Materials Science and Engineering by R. Balasubramaniam

Open Sources:

- **https://nptel.ac.in/**
- **https://www.mooc.org/**

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Living Biology and Environmental Sustainability (L:T:P-2:0:0)

Branch: All Engineering Disciplines **Semester: 3rd and 4th**
Credit-2 **Contact hour-3 hrs/week**

Prerequisite: Basic knowledge of Chemistry, biology, mathematics
Subject Code: UGE 21101

Course outcomes:
After completion of this course the students will be able to

CO1: Apply the knowledge in the field of bio-molecular domain.

CO2: Demonstrate the basic ideas of plant, viruses, bacteria and their effects in human body to apply for development of society.

CO3: Comprehend the application of overall biology in diversified field of development of mankind.

CO4: Identify the need of environmental sustainability in terms of ecosystem, air and water pollution treatment methodologies with application in real scenario with circular economy.

CO5: Solve the real life problems on various issues of waste management in the sector of solid waste, electromagnetic radiation hazard and noise pollution.

Course Details:

Unit I: Living Biology **[15 hrs]**

Cells and biomolecules:

Basic idea of cell and tissue, structure & function of different cell organelles (in brief), a comparative account on plant, animal and bacterial cell, a brief account on organic constituents of cells- carbohydrates, proteins, fats, nucleic acids (DNA & RNA), enzymes, Chromosomes and genes, Outlines of gene expression, DNA replication, transcription and translation processes, gene and chromosomal mutation, effect of environmental factors such as smoking, sunlight and radiation on mutation, Different types of mutagens and carcinogens, basic ideas on cell cycle, cell division and cancer, epigenetics, Mendel's laws of inheritance, gene interactions, twin studies

Brief account of living organisms-
Basic structure and the functions of organs and systems, plant physiological processes such as photosynthesis and respiration, Insects, Human health and diseases associated with virus and bacteria, basic structure of virus and bacteria, working principle of antibiotics, basic knowledge on immunity, immunization and vaccination, HIV and AIDS, drugs and alcohol abuse

Application of biology for society and mankind

Strategies for enhancement in food production, animal and plant breeding, plant breeding for disease resistance, pest control, improved food quality etc., Biotechnology and its applications, microbes in human welfare-microbes in industrial products, household products, fermentation, antibiotics, biogas production, biofertilizers and other uses

Common medicinal plants and their uses, plant secondary metabolites and their uses

UNIT-II: Environmental Sustainability **[15 hrs]**

Structure of Ecosystem

Structure of ecosystem - Biotic components and their organization; Function of ecosystem – Ecosystem processes including energy flow, food chain and food web; Biogeochemical cycles, Environmental gradients, Tolerance levels of environment factor. E.I.A.

Air and Water Pollution: sources and treatment

Parametric measurement of different water pollutants, COD and BOD of waste water; pre-, primary- and secondary- waste water treatment (over view); Water quality and standards and parameters; Sources of water pollution; Water treatment- pre-, primary -, secondary- and advanced water treatment processes, Sources of air pollution: source and management , ,Sustainability issues and circular economy on waste water treatment.

Solid waste , Noise pollution and other hazards: Sources and mitigation techniques

Solid waste – sources and integrated solid waste management; hazardous waste : sources and management ,e-waste source and management ,Effect on human health, Sustainable mode of mitigation , hazards of Electromagnetic radiation: sources and mitigation methods, Noise pollution: sources and mitigations ways, Circular economy on related fields.

SUBJECT NAME: Emerging materials and its applications (L:T:P-2:0:0)

SUBJECT CODE: UGE21102

Credits: 02 **Teaching Scheme:** Theory

Semester: 3rd & 4th **Contact Hours** 30

Prerequisites: Basic knowledge on fundamentals of crystal structure and origin of energy band formation

Course Objectives:

Unit 1: Material structure, Synthesis process, Properties of material and Characterization:

Crystal structure, Defects and Diffusion Mechanism, Classification of materials, Mechanical, optical and electrical properties, Synthesis of nano-materials and thin films, Structural, Electrical and Optical characterizations of materials (13 Hrs)

Unit 2: Advanced Materials and Applications

Smart Materials: Energy storage materials, Materials for energy harvesting, Materials for aeronautics application, computational Techniques for Materials, materials for flexible electronics, Materials for space communication, Materials for surface coating, Biomedical and Agricultural application of materials, Renewable energy materials, Materials for electrical and photonic devices, Hybrid composite materials for industrial application (17 Hrs)

Course Outcome:

At the end of the Course, the students will be able to

CO1: Estimate the crystal structure and its defects

CO2 Demonstrate the principles of various measurement techniques

CO3: Illustrate synthesis process of emerging materials

CO4: Analyze the emerging materials in real time applications

Text Books:

T1. Fundamentals of Materials Science and Engineering, 5th Edition, William D. Callister, Jr, John Wiley & Sons, Inc. , 2001.

T2. Materials science and Engineering - V. Raghavan, Prentice-Hall Pvt. Ltd..

Reference Books:

R1. Materials Science and Engineering, 5ed, by William F Smith, JavadHashem, Ravi Prakash, McGraw Hill Education

R2. Element of X-ray Diffraction: B. D. Cullity, Addison-Wiley, 2nd edition, 1978

R3. Materials Science, S.L.Kakani and Amit Kakani, New age international limited,

R4. F.Billmeyer, Textbook of polymer science, Wiley Interscience,1994

R5. Lewis Gladius, Selection of Engineering Materials, Pretice Hall Inc.New Jersey USA 1995

R6. J A Charles and F A ACrane,Selection and use of engineering Materials, 3rd edition , UK,1996

R7. Encyclopaedia of Materials Characterization - C.R. Brundle, C. A. Evans Jr., and S. Wilson, Butterworth- Heinemann and Manning Publications Co., 1992

Open Sources

Department of Mechanical Engineering

Subject Name: Basic Manufacturing Processes (L:T:P-3:1:3)

Regulation Year: 2020-24

Course Code: **MHE 23310** **Credit: 5**

Course Category: **Program Core** **Contact hours: 60 Hrs**

Recommended Pre-requisite:

Material Science; Mechanics of Solids; Material Science Lab

COURSE OUTCOMES: After going through this course the student will be able to

CO1: understand the principles of foundry and casting

CO2: know about the different metal forming process.

CO3: learn the modern welding processes as followed in industries

CO4: know about the processing of powder metals, ceramics and glass.

CO5: understand the processing of plastics and composite materials.

Course Details:

Unit1: **(8 Hrs.)**

Metal Casting Processes: Introduction to science of Foundry, Pattern, Pattern allowances, Pattern Materials, Types of Patterns, Sand moulding and sand testing procedure, Cores, core prints, Mechanization of moulding procedure, Squeeze machine, Design of Gating and Riser System, Shell moulding, Investment casting, Die casting, Centrifugal casting, Continuous casting., Testing of casting, Cleaning and finishing, Defects in casting. melting furnaces, Cupola, fuel-fired, electric arc and induction furnaces.

Unit 2: **(8Hrs.)**

Metal Forming Processes: Hot working, Cold working processes, Forming processes :Forging, Press forging, Die forging, Hot and Cold Rolling, Types of Rolling Mills, Extrusion- Direct and indirect Drawing- Wire drawing, tube drawing Swaging, shot-peening Sheet metal operations: Punching, Blanking, Punch and Die Clearance, Types of Dies, High Energy Rate Forming Processes: Explosive Forming – Electro Hydraulic Forming – Electro Magnetic Forming.

Unit 3: **(8Hrs.)**

Joining Processes: Classification of joining process, welding, brazing and shouldering, gas and arc Welding, gas cutting, arc welding theory, types of arc, welding efficiency, temperature distribution. Theory of TIG, MIG, Submerged arc welding and Stud welding. Resistance welding- Theory, Spot, Seam and Projection weld process. Adhesive bonding, Use of fasteners, Assembly techniques

Unit4: **(8Hrs.)**

Processing of Powder Metals, Ceramics and Glass: Production of metal powders: Compaction, Sintering and Finishing; Design considerations for powder metallurgy and Process capability – Shaping of ceramics – Forming and shaping of glass – Design considerations for ceramics and glass – Processing of superconductors.

Unit 5: **(8Hrs.)**

Processing of Plastics and Composite Materials: Types of Plastics, Types of Moulding: Injection moulding, Blow moulding, Compression moulding, Transfer moulding, Thermoforming; Reinforced plastics, Metal Matrix Composites, Ceramic Matrix Composites, Applications of these processes with specific examples

Text Books:

T1. "Manufacturing Engineering and Technology", Serope Kalpakjian and Steven R. Schmid, Prentice Hall, 6th Edition, 2010.

T2. "Manufacturing Technology Vol I", P. N. Rao, Tata Mcgraw Hill Education Private Limited, 4th Edition, 2014

Reference Books:

R1. "Processes and Materials of Manufacture", A. Lindberg, PHI / Pearson Education (India), 4th Edition, 2006.

R2. "Materials and processes in manufacturing", E. Paul Degarmo, J T Black, Ronald A Kohser, John wiley and sons, 8th Edition, 1999.

R3. "Welding Technology", R. A. Little, TMH. 5th Edition, 1973

Open Sources: NPTEL

Experiment Details: **Weightage**

List of experiments: *(Minimum 10 experiments)*	
1.	Preparation of Green sand mould using wooden pattern.
2.	Determination of Grain Fineness Number.
3.	Determination of Permeability Number.
4.	Determination of Compressive strength of moulding sand.
5.	Clay content in moulding sand.
6.	Preparation of TIG weld Lap joint.
7.	Preparation of MIG weld Lap joint.
8.	Comparison of strength of TIG and MIG welded joints.
9.	Determination of strength of brazed joint using UTM
10.	Determination of forgeability of aluminium material through Open die forging.
11.	Metal cutting by gas cutting process.
12.	Sample preparation using powder metallurgy technique.

Open Sources/Virtual lab: ---.

Subject Name: Fluid Mechanics & Hydraulic Machines (L:T:P-3:0:3)

Regulation Year: 2020-24

Course Code: MHE 23314 **Credit: 5**

Course Category: Program Core **Contact hours: 42**

Recommended Pre-requisite:Engineering Mechanics; Mathematics- I & II

COURSE OUTCOMES:After going through this course the student will be able to

CO1: Analyze the fluid properties & solve problems related to fluid at rest.

CO2: Analyze the flow visualization & solve fluid flow problems using impulse-momentum principle and Bernoulli's Equation.

CO3: Calculate energy losses and drag during internal & external fluid flows.

CO4: Design hydraulic turbines (Pelton/Francis/Kaplan) & hydraulic pumps (Centrifugal/Reciprocating).

CO5: Perform dimensional analysis for any model and prototype set.

Course Details:

Unit1: **(08Hrs.)**

Introduction

Scope of fluid mechanics and its development as a science; Physical property of Fluid: Density, specific gravity, specific weight, specific volume, surface tension and capillarity, viscosity, compressibility and bulk modulus; Fluid classification.

Fluid Statics

Fluid Pressure: Pascal's Law, Pressure variation for incompressible fluid, atmospheric pressure, absolute pressure, gauge pressure and vacuum pressure, manometer; Hydrostatic process on submerged surface: Inclined plane surfaces and curved surfaces; Buoyancy and floatation: Archimedes' principle, stability of immersed and floating bodies, determination of metacentric height.

Unit2: **(08Hrs.)**

Fluid Kinematics

Eulerian and Lagrangian description of fluid flow; Flow visualization: *stream, streak and path lines*; Fluid Deformation; Concept of system and control volume; Reynolds transport theorem; Continuity equation; Fluid flow classification; Rotation, vorticity and circulation; Stream and potential functions.

Fluid Dynamics

Impulse momentum relationship and its applications; Navier stokes equation (introductory only); Euler's equation; Bernoulli's equation.

Unit 3: **(10 Hrs.)**

Internal Flows

Concept of fully developed flow; Laminar Flow: Analysis of unidirectional flow between parallel plates, Flow regimes and Reynolds number, Hagen-Poiseuille flow;Turbulent Flow: Introduction, velocity profile; Losses in pipes: Major & minor losses, hydraulic gradient and total energy lines; Compound pipes: series and parallel connection of pipes; Power transmission: Through pipes & nozzles.

External Flows

Boundary Layer Flow: Concept, displacement, momentum and energy thickness, Von-karman momentum integral equation, laminar and turbulent boundary layer flows, boundary layer separation and control, concept of drag and lift.

Unit4: **(10Hrs.)**

Hydraulic Turbines

Introduction: Classification; Impulse turbine: Pelton turbine-velocity triangles, analysis; Reaction turbines: Francis turbine- velocity triangles & analysis, Kaplan turbine- velocity triangles & analysis.

Hydraulic Pumps

Introduction: Classification; Centrifugal pump: Velocity triangles & analysis; Reciprocating pumps: Indicator diagram & analysis.

Unit5: **(06 Hrs.)**

Dimensional Analysis

Introduction: Dimension, Dimensional Homogeneity; Methods of dimensional analysis: Rayleigh Method & Buckingham л-Method.

Principles of Physical Similarity

Similitude: Types of Similarities, Geometric Similarity, Kinematic Similarity, Dynamic Similarity, Force Ratios; Dimensionless Numbers; Similarity Laws or Model Laws; Types of Models; Merits and Limitations of Distorted Models.

Text Books:

T1: Introduction to Fluid Mechanics and Fluid Machines, S. K. Som and G. Biswas, TMH, Latest Edition.

T2: Fluid Mechanics and Hydraulic Machines, Modi & Seth, Standard Book House, Latest Edition.

T3: Fluid Mechanics by Yunus A. Cengel& John M. Cimbala, TMH, Latest Edition.

Reference Books:

R1. Fluid Mechanics, A. K. Mohanty, PHI, Latest Edition.

R2. Introduction to Fluid Mechanics, Fox, McDonald, Willey Publications, Latest Edition.

R3. Fluid Mechanics, P K Kundu, Elsevier, Latest Edition.

R4. Fluid Mechanics, J. F. Douglas, J. M. Gasiorek, J. A. Swaffield and L. B. Jack, Pearson Education, Latest Edition.

R5. Fluid Mechanics, F. M. White, McGraw-Hill Publication, Latest Edition.

Open Sources:

SWAYAM; COURSERA; ANY OTHER MOOC PLATFORM

ExperimentDetails: **Weightage**

Experiment 1: Determination of Metacentric Height and its application to stability of floating bodies.

Experiment 2: Verification of Bernoulli's Theorem.

Experiment 3: Determination of Coefficient of discharge (Cd) on Venturimeter Apparatus.

Experiment 4: Determination of flow velocity by Pitot tube.

Experiment 5: Experiments on impact of Jets.

Experiment 6: Experiments on performance of Pelton Turbine.

Experiment 7: Experiments on performance of Francis Turbine.

Experiment 8: Experiments on performance of Kaplan Turbine.

Experiment 9: Experiments on performance of centrifugal pump.

Experiment 10: Experiments on performance of reciprocating pump.

Experiment 11: Determination of Cavitation Number on a Cavitation Apparatus.

Experiment 12: Experiments on performance of Gear Pump.

Open Sources/Virtual lab: Nil

Department of Mechanical Engineering

Subject Name: Metrology Quality Control and Reliability (L:T:P-3:1:0)

Regulation Year: 2020-24

Course Code: MHE 21316 **Credit: 3**

Course Category: Program Core **Contact hours: 40 Hrs**

Recommended Pre-requisite:

- **Material Science**
- **Basic Manufacturing Processes**

COURSE OUTCOMES:

CO 1: Design Go and No Go gauges based on principles of limits, fits, and tolerance.

CO 2: Apply knowledge of various instruments and methods to determine geometry and surface finish as well as dimensions of industrial components.

CO 3: Select and design an acceptance sampling plan for sampling inspection.

CO 4: Select and design an acceptance sampling plan for sampling inspection.

CO 5: Analyze reliability data and predict the reliability of individual components as well as the entire system.

Course Details:

Unit1: **(8 Hrs.)**

Introduction: Metrology defined, Needs of inspection, Principles, and methods of measurement, Precision and accuracy, Sources of error, Random and Systematic error, Standards of measurement:- Line, End and Wavelength standards, Interchangeability, Selective assembly, Limits, Fits and Tolerances, Fundamental deviation, Hole and Shaft basis systems, Limit gauges, Taylor's principles of designs of limit gauges.

Unit2: **(8Hrs.)**

Inspection of Geometric Parameters, Surface Finish and Screw Thread Elements: Measurement of straightness, flatness, parallelism, squareness and roundness (circularity). Surface Texture: Meaning of CLA and RMS values, Grades of Roughness, Surface roughness measurement methods. Measurement of effective diameter of screw thread using 2-wire and 3-wire methods.

Unit 3: **(8Hrs.)**

U3.1. **Fundamental of Quality Control:**Meaning of Quality, Characteristics of Quality, Product quality vs Service quality, Cost of Quality, Voice of Customer, Quality Function Deployment.Testing of Hypothesis, Type-I & Type-II error, Control limit theorem.Acceptance sampling, 100% inspection vs sampling inspection, Producer's Risk and Consumer's Risk, Operating Characteristic Curve, Concept of AOQ, ATI, ASN, Single sampling plan vs Double sampling plan, Design of single sampling plan.

Unit4: **(8Hrs.)**

Statistical Process Control: Concepts of Variations, Random and Assignable causes of variation, Natural tolerance limits, Specification limits, Control charts for variables, Control chart for attributes, Concept of Process Capability, Process Capability Indices.

Unit 5: **(8Hrs.)**

Reliability: Definition, bath –tub curve, System reliability and reliability improvement, MTTF, MTBF, Availability of single repairable system using Markov model, Life tests. Maintainability, Availability.

TextBooks:

TextBooks:

T1. "Engineering Metrology", R.K. Jain, Khanna Publisher, Delhi, 20th Edition, 2004.

T2. "Fundamentals of Quality Control and Improvement", A. Mitra,Wiley India Pvt Ltd, 3rd Edition, 2013.

T3. "Terotechnology-Reliability Engineering and maintenance", B. Bhadury, S. K. Basu, Asian books Pvt. Ltd, 1st Edition, 2003.

ReferenceBooks:

R1. "A text book of Engineering Metrology", I.C. Gupta,Dhanpat Rai & Sons, 7th Edition, 2012.

R2. "Introduction to Statistical Quality Control", D.C. Montgomery,John Wiley and Sons, 4th Edition, 2008.

R3. "Quality Control", D.H. Besterfield, Pearson Education, 7th Edition, 2006.

R4. "Practical Engineering Metrology", K.W.B. Sharp, Pitman Publication, 1970.

R5. "Handbook of industrial metrology", ASTE, Prentice hall of India ltd, 1st Edition, 2007.

Open sources:

- http://nptel.ac.in
- https://www.vssut.ac.in/lecture_notes/lecture1424082946.pdf/
- http://www.myopencourses.com/discipline/mechanical-engineering

Department of Mechanical Engineering

Subject Name: Mechanics of Machines (L:T:P-3:0:3)

Regulation Year: 2020 – 24

Course Code: MHE 23318 **Credit: 05**

Course Category: Program Core **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. **Engineering Mechanics**
2. **Mechanics of Solids**
3. **Mathematics – I , II ,III**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Apply different mechanisms for designing machines and analyse position, velocity and acceleration kinematics of mechanisms

CO2: Apply the principles for analysing cams, gears and gear trains.

CO3: Analyse dynamic forces acting on mechanism.

CO4: Balance of rotating and reciprocating masses. Measure and analyse free, forced and damped vibrations of mechanical systems

CO5: Develop concepts of speed control systems for engines, and analyse gyroscopic effects on aeroplanes and ships

Course Details:

Unit1: Basics of Mechanisms **(10 Hrs.)**

Introduction, Terminologies, Degree of Freedom, Study of planar mechanisms and their inversions. Velocity and accelerations in planar mechanisms

Unit2: Kinematics of Cams, Gears and Gear Trains **(7 Hrs.)**

Cams with different Follower Motion, Gear terminologies - Law of gearing - Interference, Types of gear trains

Unit3: Dynamic Force Analysis **(8 Hrs.)**

D'Alembert's Principle, Dynamic Analysis of planar Mechanism. Turning Moment Diagrams - Fly Wheels - Applications

Unit4: Balancing and Vibration **(7 Hrs.)**

Static and Dynamic Balancing of Rotating Masses, Balancing of Reciprocating Masses, Introduction to vibration - Terminologies - Single degree of freedom- damped and undamped- free and forced vibration

Unit5: Mechanisms for Control & Gyroscope **(8 Hrs.)**

Governors- types and its characteristics, Gyroscopic Effects on the Movement of Air Planes and Ships – Gyroscope Stabilization

Text Books:

1. S. S. Rattan, Theory of Machines, Tata McGraw Hill.
2. A. Ghosh and A. K. Mallick, Theory of Mechanisms and Machines, East-West Pvt. Ltd.
3. Thomas Bevan, Theory of Machines, , CBS Publishers and Distributors.
4. V.P. Singh, Mechanical Vibrations, Dhanpat Rai & company Pvt. Ltd.

Reference Books:

1. J.S. Rao.and R.V. Dukkipati, Mechanisms and Machine Theory, Wiley-Eastern Ltd.
2. J.J. Uicker, G.R. Pennock and J.E. Shigley, Theory of Machines and Mechanisms, Oxford University Press.
3. Robert L. Norton, Kinematics and Dynamics of Machinery, Tata McGraw-Hill.
4. S.S. Rao, Mechanical Vibrations, Pearson Education Inc.
5. W.T. Thomson and Marie Dillon Dahleh, Theory of vibration with Applications, Pearson Education.

Open Sources:

https://nptel.ac.in

https://ocw.mit.edu/courses/mechanical-engineering/

https://www.classcentral.com/provider/swayam

https://www.coursera.org/in

https://www.mooc.org/

Experiment Details: **Weightages**

Experiment 1	Identification of kinematic links, pairs and chains in a mechanism and identify the inversions of a four bar mechanisms	**Exercise (10 Marks) / Project (25 Marks)**
Experiment 2	Analysis of Cam and follower mechanism and plotting the Cam profile	**Structured Enquiry (15)**
Experiment 3	Study of different toothed gear and gear trains	**Demonstration (10 Marks)**
Experiment 4	Determination of moment of inertia and angular acceleration of the flywheel	**Structured Enquiry (15)**
Experiment 5	Determination of balancing mass for complete balancing by drawing force and couple polygon.	**Exercise (10 Marks)**
Experiment 6	Free vibration analysis of spring mass system	**Structured Enquiry (15)**
Experiment 7	Determination of damping coefficient of plates	**Open ended Enquiry (20)**
Experiment 8	Determination of controlling force at a given speed, governor effort & power for a Hartnell governor.	**Structured Enquiry (15)**
Experiment 9	Determination of Gyroscopic couple on a rotating disc	**Structured Enquiry (15)**

Open Sources/Virtual lab:

http://mm-nitk.vlabs.ac.in/#

http://vlabs.iitkgp.ac.in/mr/#

http://mdmv-nitk.vlabs.ac.in/#

https://dom-nitk.vlabs.ac.in/

Department of Mechanical Engineering

Subject Name: Machine Design (L:T:P-3:1:0)

Regulation Year: 2020 – 24

Course Code: MHE 21317 **Credit: 03**

Course Category: Program Core **Contact hours: 40 hrs**

Recommended Pre-requisite:

1. **Engineering Mechanics**
2. **Mechanics of Solids**
3. **Basic Manufacturing Processes**
4. **Kinematics and Dynamics of Machines**

Data Book/Codes/Standards:

1. "Design Hand Book", S.M. Jalaluddin; Anuradha Agencies Publications
2. "P.S.G. Design Data Hand Book", PSG College of Tech Coimbatore
3. "Machine Design Data Book", K. Lingaiah, Tata McGraw Hill

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Explain basic principles involved in the machine design.

CO2: Design and analyze permanent and temporary joints and power transmission shafts under various loading conditions.

CO3: Design and analysis of couplings and springs with different geometrical features under various loading conditions

CO4: Analyze operating conditions of Journal bearings, and use manufacturer's catalogue for selection of rolling contact bearings

CO5: Identify, evaluate, compare and design different power transmission and absorption components like gears, clutches, and brakes. Perform strength design of IC engine components like Piston

THEORY PART (CONTENTS)

Unit 1: Fundamentals of Machine Design **(7 Hrs.)**

Unit 1.1:

Static Loads, Types of stresses, Different Criteria for Design, Design Process, Design considerations, Factors influencing machine design, Standardization and Interchangeability of machine elements, Allowable stress, Factor of safety, Service factor, Concept of stress concentration, Notch sensitivity, Methods of relieving stress concentration, Concept of fatigue, Types of Fatigue loading, Fatigue cycle regimes, Failure models, S-N Curve for reversed loading, Soderberg, Modified Goodman and Gerber design criteria, Design against fluctuating normal, shear and combined stresses

Unit 1.2:

Maximum Principal Stress and maximum shear stress for combined axial, bending and shear loading, Fatigue test methods, Cumulative fatigue.

Unit 2: Design of Joints and Shafts **(11 Hrs.)**

Unit 2.1:

Temporary Joints: Socket and spigot cotter joint, Knuckle joint

Permanent Joints: Riveted joints: Types, Modes of failure, boiler joint, Welded joints: Types, Design for various loading conditions

Shafts: Maximum Principal Stress and maximum shear stress for combined axial, bending and torsional loading in shafts, Materials, Standard sizes.

Unit 2.2:

Sleeve and Cotter, Structural riveted joint, Basic weld symbols, Design of Feather key, Woodruff key, Tangent key, Taper pin,

Unit 3: Design of Keys, Couplings and Springs **(8 Hrs.)**

Unit 3.1:

Keys and Couplings: Types, Design of Regtangular sunk key, Design of Rigid Flange Coupling

Springs: Stress and deflection equations for helical compression Springs, Types of ends, Design of helical compression and tension springs, Helical torsion Spring, Surge in springs, Design of semi-elliptical leaf springs.

Unit 3.2:

Design of Flexible Bushed pin Coupling, Types, applications and materials for springs

Unit 4: Design of Bearings **(7 Hrs.)**

Unit 4.1:

Lubrication: Hydrostatic and Hydrodynamic lubrication, Types of Lubricants, Viscosity chart.

Sliding Contact Bearing: Types, Description of Journal bearing, Raimondi & Boyd method for design of journal bearing.

Rolling Contact Bearing: Types, Structural features, Design considerations, Static LCC, Rating life, Dynamic LCC, Selection of Ball and Cylindrical roller bearings, Design for different confidence levels and variable loading

Unit 4.2:

Pedestal bearing, Foot step bearing

Unit 5: Design of Transmission Members and IC Engine Component **(7 Hrs.)**

Unit 5.1:

Spur Gears: Standard tooth systems, Force analysis, Tooth failure, Strength design, Wear design.

Friction Clutches: Design of Disc clutch and Cone clutch.

Brakes: Design of Block and Band brake.

Design of Piston: Design considerations, Materials, Design of piston head or crown, Piston rings, Piston barrel, Piston skirt, Piston pin.

Unit 5.2:

Design of cylinder, Design of connecting rod, Design of crank shaft

Note:
At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

TUTORIAL PART (CONTENTS)

1. Designing of shafts on the basis of failure criteria
2. Designing of temporary joints
3. Designing of permanenet joints
4. Designing of shafts
5. Designing of couplings
6. Designing of springs
7. Designing of journal bearing
8. Designing of clutch
9. Designing of brakes
10. Designing of gears
11. Designing of Piston
12. Designing of rolling contact bearing

Text Books:

T1:- "Mechanical Engineerng Design", J.E. Shigley, C.R. Mischke, R.G. Budynas and K.J. Nisbett, Tata McGraw-Hill , 8th Edition, 2008

T2: Design of Machine Elements", V.B. Bhandari, Tata McGraw-Hill, 3rd Edition, 2010.

T3: "A Text Book of Machine Design", R.S. Khurmi and J.K. Gupta, S.Chand Publication, 14th Edition, 2005

Reference Books:

R1. "Design of Machine Elements", M.F. Spotts, T.E. Shoup and L.E. Hornberger, Pearson/Prentice Hall, 8th Edition, 2007.

R2. "Machine Design", P.C. Sharma and D.K. Agrawal, S.K.Kataria & Sons, 11th Edition, 2007.

R3. "Machine Design", R.L. Norton, Pearson Education Asia, 5th Edition, 2001.

R4. "Fundamental of Machine Component Design", R.C. Juvinall and K.M. Marshek, Wiley India Pvt. Ltd., New Delhi, 3rd Edition, 2007

R5. "Machine Design", P. Kanaiah, Scietech Publications, 2nd Edition, 2008

OPEN SOURCES:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering/
- http://www.myopencourses.com/discipline/mechanical-engineering

Mechanical Engineering Department

Subject Name: Heat Transfer (L:T:P-3:1:3)

Regulation Year: 2020-24/2021-25

Course Code: MHE 23319 **Credit:** 5

Course Category: Program Core **Contact hours:** 40

Recommended Pre-requisite: Basic Thermodynamics, Mathematics I, II, and III (Partial Differential Equation & Complex Analysis**)**

COURSE OUTCOMES: After going through this course the student will be able to **(*Collective for theory & lab parts*)**

CO1: Understand the basic laws of heat transfer and their application in thermal analysis of engineering systems for different boundary conditions.

CO2: Determine temperature distribution in simple geometries using steady state heat conduction equation

CO3: Analyze the performance of fins and develop solutions for transient heat conduction in simple geometries

CO4: Analyze the performance of fins and develop solutions for transient heat conduction in simple geometries

CO5: Evaluate the radiative heat transfer between surfaces

THEORY PART (CONTENTS)

Unit 1: **(5 Hrs)**

Introduction

Modes of heat transfer: Conduction, Convection, and Radiation, Mechanism & basic laws governing conduction, convection, and radiation heat transfer; Thermal conductivity, Thermal Conductivity in metal and nonmetals, liquids and gases, Thermal conductance & thermal resistance, Contact resistance, convective heat transfer coefficient, radiation heat transfer coefficient, Electrical analogy, combined modes of heat transfer, Initial conditions and Boundary conditions of 1st, 2nd and 3rd kind,

Unit 2: **(5 Hrs)**

One Dimensional Heat Conduction

General heat conduction in Cartesian co-ordinates, Simplification of the general equation for one and two dimensional steady/ transient conduction with constant/ variable thermal conductivity with / without heat generation, Solution of the one dimensional steady state heat conduction problem in case of plane walls, cylinders and spheres for simple and composite cases, Critical insulation thickness, Generalized heat conduction equation in cylindrical and spherical coordinates.

Unit 3: **(5 Hrs)**

Heat transfer from extended surfaces and Lumped system analysis

Heat transfer from extended surfaces (pin fins only) without heat generation, Long fin, short fin with insulated tip and without insulated tip and fin connected between two heat sources. Fin efficiency and fin effectiveness, Conduction in solids with negligible internal temperature gradient (Lumped heat analysis), Solution of Cartesian problems in two dimensions (steady state conduction with constant thermal conductivity and no heat generation) by variable separation method, Numerical methods for heat conduction analysis, Variable separation method for solving 2D heat conduction, Gauss-Seidel method.

Unit 4: **(15 Hrs)**

Mechanism of convection, boundary layer fundamentals.

Forced Convection (External): Conservation of mass, momentum and energy equation for 2-D laminar flow over a flat plate. Reynolds-Coulbourn analogy for Turbulent flow over a flat plate. Use of empirical relations for solving turbulent conditions for external flow.

Forced Convection (Internal): Forced Convection inside tubes and ducts (velocity and temperature profiles). Analysis of laminar forced convection inside a tube. Evaluation of heat transfer coefficients for laminar flow (Constant heat flux and constant temperature). Use of empirical relations for solving flow inside circular and non-circular tubes.

Natural Convection: Mechanism of heat transfer during natural convection, Experimental heat transfer correlations for natural convection in the following cases (a) Vertical and horizontal plates (b) Inside and outside flows in case of tubes.

Condensation and Boiling: Film wise and drop wise condensation – Film condensation on a vertical plate – Regimes of Boiling – Forced convection boiling.

Unit 5: **(10 Hrs)**

Radiation: Introduction to radiation, Solar radiation, Radiation Intensity, Laws of radiation: Planck's law, Wein's displacement law and Stefan Boltzmann law, Kirchhoff's law, Radiative properties, Concepts of black body & grey body, View factor, Electrical analogy, Radiation exchange between surfaces, Radiation shield.

Heat Exchangers: Types and practical applications, use of LMTD & Effectiveness – NTU method, fouling factor, Practical applications of heat exchangers,.

Note:
At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)-*If any*

<u>List of experiments:</u> *(Minimum 10 experiments)*

1. Determination of Thermal conductivity of composite slab
2. Determination of thermal conductivity of insulating powder
3. Efficiency and effectiveness of fins (Natural convection).
4. Efficiency and effectiveness of fins (Forced convection).
5. Natural convection heat transfer from a heated vertical cylinder
6. Heat transfer in forced convection for internal flow in a pipe.
7. Performance of a parallel flow and counter flow heat exchanger
8. Performance of shell and tube heat exchanger
9. Determination of critical heat flux.
10. Verification of Stefan Boltzmann's law
11. Determination of surface emissivity
12. Study of heat pipe and its demonstration

Text Books:

T1: Heat Transfer, P. K. Nag, TMH, 3rd Edition, 2011

T2: Heat Transfer, J. P. Holman, TMH, 9th Edition, 2008

T3: Basic Heat Transfer, Necati Ozisik, McGraw Hill Publication, 1984

Reference Books:

R1. Heat Transfer, P. S. Ghosdastidar, Oxford University Press, 2nd Revised Edition, 2012.

R2. Heat Transfer, S. P. Sukhatme, University Press, 2006.

R3. Heat Transfer, A. F. Mills and V. Ganesan, Pearson Education, 2nd Edition, 1992.

R4. Heat and Mass Transfer, Domkundwar and Arora, Danpatrai and sons, Paper Back Edition, 2005.

R5. Heat and Mass Transfer - A Practical Approach, Y. A. Cengel, Tata McGraw Hills, 3rd Revised Edition, 2006.

R6. Heat Transfer, R.K.Rajput, S. Chand Publications, Revised Edition, 2012.

R7. Heat and Mass Transfer - A Practical Approach, Y. A. Cengel, Tata McGraw Hills, 3rd Revised Edition, 2006

R8. Fundamentals of Heat and Mass Transfer, Incropera and DeWitt, Wiley Publication, 6th Edition, 2010.

Open Sources:

- NPTEL: nptel.ac.in/courses/112101097/
- MIT open course ware: http://ocw.mit.edu/courses/mechanical-engineering/2-51-intermediate-heat-and-mass-transfer-fall-2008/study-materials/.

Department of Mechanical Engineering

Subject Name: Metal Cutting - Theory and Practice (L:T:P-3:0:3)

Regulation Year: 2020-24/ 2021-25

Course Code: MHE 23320 **Credit: 5**

Course Category: Program Core **Contact hours: 60 Hrs**

Recommended Pre-requisite:

- **Material Science**
- **Basic Manufacturing Processes**

COURSE OUTCOMES:

CO 1: Explain the ASA, ORS and NRS systems of tool geometry and derive their interrelationships.

CO 2: Develop the relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy and temperatures associated with orthogonal cutting.

CO 3: Select cutting fluids, cutting tool materials and tool geometry for improving machinability and tool life.

CO 4: Describe different types of surface finish processes.

CO 5: Explain various types of machine tool and their operations.

Course Details:

Unit 1: **(8 Hrs.)**

Introduction: Classification of manufacturing processes, History of machining, Scope and significance of machining.

Geometry of Cutting Tools: Geometry of single-point cutting tool, Tool-in hand system, ASA system, Significance of various angles of single point cutting tools, Orthogonal Rake System (ORS), Conversions between ASA and ORS systems – Graphical and Analytical Methods, Normal Rake System (NRS) & relation with ORS.

Unit 2: **(8 Hrs.)**

Mechanics of Machining Processes: Orthogonal and Oblique cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process – Various forces, power and specific energy in cutting.

Unit 3: **(8 Hrs.)**

Thermal aspects in Machining: Sources of heat generation, Effects of temperature, Determination of cutting temperature, Methods of Controlling Cutting Temperature.

Tool Wear and Tool Life: Wear Mechanisms, Types of tool wear, Tool Life and Machinability.

Cutting Tool Materials: Desirable Properties of tool materials, Characteristics of Cutting Tool Materials.

Cutting Fluids: Functions, characteristics and types, Selection of cutting fluids.

Unit 4: **(8 Hrs.)**

Surface Finish Process: Introduction to grinding, Classification of grinding machines, Different types of abrasives, bonds, specification and selection of a grinding wheel, Lapping, Honing & Broaching operations, comparison to grinding.

Unit 5: **(8 Hrs.)**

Machine Tools: Introduction, Classification, Construction and specifications (Simple sketches showing major parts of the machines) - Lathe, Milling machine, Drilling machine, Boring machine, Broaching machine, Shaping machine, Planing machine, Classification of Jigs & Fixtures, Principles of location and clamping, Types of clamping & work holding devices, Typical examples of jigs and fixtures.

Text Books:

T1: "*Manufacturing Technology – Metal Cutting and Machine Tools*", P. N. Rao, TMH publication.

T2: "*A Text Book of Production Engineering*", P. C. Sharma, S. Chand publication.

T3: "*Manufacturing Engineering and Technology*", S. Kapakjian and S. R. Schmid, Pearson Education (Singapore) publication.

Reference Books:

R1. "*Metal Cutting: Theory and Practice*", A. Bhattacharya, New Central Book Agency, Kolkata.

R2. "*Manufacturing Science*", A. Ghosh and A. K. Mallick, Affiliated East West Press.

R3. "*Introduction to Jigs and fixtures design*", M. H. A. Kempster, The English University Press.

R4. "*Fundamentals of Metal Machining and Machine Tools*", G. Boothroyd and W. A. Knight, Taylor & Francis publication.

Open Sources:

- **https://nptel.ac.in/**
- **https://www.mooc.org/**

Experiment Details:		Weightage
Experiment 1:	Preparation of a single point cutting tool with a given tool geometry.	
Experiment 2:	Estimation of chip reduction coefficient and shear angle in orthogonal turning.	
Experiment 3:	Turning, taper turning, eccentric turning and chamfering on lathe machine.	
Experiment 4:	Thread cutting and knurling on lather machine.	
Experiment 5:	Evaluation of the effect of process parameters on surface roughness in turning.	
Experiment 6:	Estimation of tool life of a single point turning tool.	
Experiment 7:	Measurement of cutting forces and average cutting temperature in turning process.	
Experiment 8:	Manufacture of spur and helical gears on a milling machine.	
Experiment 9:	Effect of process parameters on surface finish and forces in surface grinding operation.	
Experiment 10:	Conversion of a cylindrical shaft to a square shaft by shaping process.	
Experiment 11:	Drilling and Tapping operation.	
Experiment 12:	Keyways preparation by slotting machine.	

Open Sources/Virtual lab: ---.

Department of Mechanical Engineering

Subject Name: Advanced Mechanics of Solids (L:T:P-3:0:3)

Regulation Year: 2020 – 24 / 2021-25

Course Code: MHE 23413 **Credit: 05**

Course Category: Program Elective **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. **Engineering Mechanics**
2. **Mechanics of Solids**
3. **Engineering Mathematics**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Determine the deflection produced in a beam by energy method

CO2: Perform stress and strain analysis of curved beams and thick cylindrical pressure vessels.

CO3: Analyze three dimensional stresses in solids

CO4: Analyze three dimensional strains in solids

CO5: Explain the mechanics of composite materials

Course Details:

THEORY PART (CONTENTS)

Unit 1: Energy Methods **(09 Hrs.)**

Unit 1.1: Elastic strain energy due to normal stress and shearing stress, Principle of virtual work, Unit load and unit couple method, Castigliano's theorem and its application to beams

Unit 1.2: Maxwell's reciprocal theorem, Betti-Rayleigh reciprocal theorem

Unit 2: Bending of Beams and Axisymmetric Problems **(13 Hrs.)**

Unit 2.1:

Bending of beams: Unsymmetrical bending of beams, Bending of curved beams, Stress distribution in curved beams with rectangular, circular and trapezoidal cross section, Stresses in crane hooks, Shear centre

Axisymmetric problems: Thick walled cylinder subjected to internal and external pressures, Compound cylinders, Shrink fit.

Unit 2.2: Stresses in ring and chain links, Deflection of thick curved bars

Unit 3: Three Dimensional Stress Analysis **(07 Hrs.)**

Unit 3.1: Elementary concept of elasticity, stresses in three dimensions, Principal Stresses, Stress Invariants, Mohr's Circle for 3-D state of stress, Octahedral Stresses, State of pure shear

Unit 3.2: Differential equations of equilibrium

Unit 4: Three Dimensional Strain Analysis **(05 Hrs.)**

Unit 4.1:Displacement field, State of strain at a point, Strain-Displacement relations, Principal Strains, strain Invariant, Principal directions
Unit 4.2: Strain-Compatibility relations

Unit 5: Introduction to Mechanics of Composite Materials **(06 Hrs.)**

Unit 5.1: Introduction to composite materials, Applications, Stress-strain relations, Basic cases of elastic symmetry, Micromechanical behavior of a lamina

Unit 5.2: Macro mechanical behavior of a lamina

Note:
At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB (Using Creo/ANSYS)

List of experiments: *(Minimum 10 experiments)*

1. Analysis of Symmetrical beams under different loading conditions.
2. Analysis of Unsymmetrical beams under different loading conditions.
3. Analysis of plates under different loading conditions .
4. Analysis of plates (with holes and notches) under different loading conditions.
5. Analysis of Truss under different loading conditions.
6. Analysis of Truss under different loading conditions.
7. Analysis of shafts under different loading conditions (Torsion).
8. Analysis of shafts under different loading conditions (Torsion and Bending).
9. Analysis of helical coil spring
10. Analysis of Thick Pressure Vessels (Cylinder and Sphere)
11. Analysis of Thick Pressure Vessels (Compound Cylinder and Sphere).

Text Books:

T1. "Advanced Mechanics of Solids", L.S. Srinath, Tata McGraw-Hill Publishing Company Limited, Third Edition, 2009.
T2. "Advanced Mechanics of Materials", A.P.Boresi and R.J. Schmidt, John Wiley & Sons, Sixth Edition, 2003.
T3. "Advanced Mechanics of Materials", K. Kumar and R.C. Ghai, Khanna Publisher, Seventh Edition, 2008.

Reference Books:

R1. "Mechanics of Materials", Ferdinand P. Beer, E. Russell Johnston Jr., Johnston T. DeWolf, and David F. Mazurek, Tata Mcgraw Hill Education Private Limited, Fifth Edition, 2011.
R2. "Mechanics of Composite Materials", R.M. Jones, Taylor & Francis, Second Edition, 1999.

R3. "Strength of Materials", Dr. Sadhu Singh, Khanna Publishers, Eleventh Edition, 2014.
R4. "Mechanics of Materials", R.C Hibbeler, Printice Hall, Ninth Edition, 2013.
R5. "Strength of Materials", S.S Ratan, Tata Mcgraw Hill Education Private Limited, Second Edition, 2008.

Open sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering/
- http://www.myopencourses.com/discipline/mechanical-engineering

Subject Name: Internal Combustion Engine and Gas Turbine (L:T:P-3:0:3)

Regulation Year: 2020-24/2021-25

Course Code: MHE 23415 **Credit:** 5

Course Category: Program Elective **Contact hours:** 40

Recommended Pre-requisite: Basic Thermodynamics, Fluid Mechanics, Engg Chemistry, Material Science

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Understand basic engine function, performance, design methodology and performance analysis of different IC Engine cycles.

CO2: Describe different Air and Fuel induction techniques for SI and CI Engines and understand Ignition system.

CO3: Understand combustion characteristics for SI and CI Engines with Supercharging and Scavenging concept.

CO4: Perform Testing of Performance of IC engine and understand engine Cooling, Lubrication, engine emission system.

CO5: Understand Gas Turbine Engine, its working and various modified gas turbine engines for enhanced performance.

THEORY PART (CONTENTS)

Unit 1: **(10 Hrs)**

Introduction

Classification, Engine nomenclature, engine operating and performance parameters, Valve timing diagram of SI & CI Engines, Comparison of SI and CI engine.

IC Engine Cycles: Air standard cycles, Assumptions, Otto, Diesel, Dual Combustion Cycles, Comparison of Otto, Diesel and Dual cycles, Fuel-air cycles, Effect of variable specific heat, dissociation and operating variables on performance, Actual cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blow down, Loss Due to Gas Exchange Processes, Volumetric Efficiency, Loss due to Rubbing Friction, Numerical on Fuel-Air cycle.

Unit 2: **(10 Hrs)**

Fuels: Types of IC Engine fuels, Qualities of IC Engine fuels, rating of fuels, Alternative Fuels

Carburetion: Factors Affecting Carburetion, Mixture requirements, Principle of Carburetion, Simple Carburetor and its drawbacks, Calculation of the Air–Fuel Ratio, Solex Carburetor.

Fuel Injection: Functional Requirements of an Injection System, Classification of Injection Systems, Fuel Feed Pump, Injection Pump, working of Injection Pump Governor, (Mechanical Governor, Pneumatic Governor) Fuel Injector, Nozzle, Injection in SI Engine, Modern developments in Petrol and Diesel Injection System.

Ignition: Requirements of an ignition system, conventional ignition systems, firing order, Ignition timing, Spark advance mechanism, Modern ignition systems (TCI and CDI).

Unit 3: (8 Hrs)

Combustion: Stages of combustion in SI and CI engines, effects of engine variables on flame propagation and ignition delay, abnormal combustion, Pre-ignition & Detonation, Theory of Detonation. Effect of engine variables on Detonation, Control of Detonation. Diesel Knock & methods to control diesel knock, Requirements of combustion chambers. Features of different types of combustion chambers system for S.I. engines and CI. engines.

Super Charging & Scavenging: Supercharging, Effect of supercharging, Methods of super charging, supercharging and scavenging of 2-stroke engines.

Unit 4: (7 Hrs)

Testing and Performances: Power, fuel & air measurement methods, Performance characteristic curves of SI & CI engines, variables affecting performance and methods to improve engine performance.

Cooling & Lubricating Systems: Air cooling & water-cooling systems, Effect of cooling on power output & efficiency, Properties of lubricants and different types of lubricating system.

Engine Emission & Controls: Mechanism of pollutant formation and its harmful effects. Methods of measuring pollutants and control of engine emission.

Modern developments in IC Engines: EGR, GDI, HCCI, dual fuel engine, Lean burn engine, Stratified engine (basic principles).

Unit5: (5 Hrs)

Gas Turbines: Introduction, Open and closed cycle gas turbines, Brayton cycles, The Brayton cycle with non-isentropic flow in compressors and turbines, The Brayton cycle with regeneration, reheating and intercooling, Combined Steam Gas Cycle.

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)

List of experiments: *(Minimum 10 experiments)*

1. Load test on 4-stroke single cylinder C.I. engine
2. Load test on 4-stroke single cylinder S.I. engine.
3. Load test on variable compression ratio S.I. engine.
4. Morse Test on multi-cylinder S.I. or C.I. engine.
5. Valve timing diagram of an IC engine.
6. Study of a modern carburetor (e.g. Solex Carburtor).
7. Study of fuel injection system of a diesel engine.
8. Analysis of exhaust gas of automobile.
9. Study of different cooling systems in automobiles (Air cooling and water cooling).
10. Study of lubrication systems in automobiles.
11. Heat balance on Multi Cylinder S.I. Engine.

Text Books:

T1: Internal Combustion Engines, V. Ganesan, TMH, 4^{th} Edition,2012.

T2: Fundamentals of Internal Combustion Engines, Poul. W. Gill, James H. Smith, Jr. E.J.Zirus, Oxford, 4th Revised Edition, 2007.

T3: IC Engines and Gas Turbine, Mathur & Sharma, Dhanpat Rai & Sons, Paperback Edition, 2010.

T4: Steam and gas Turbine, R Yadav, Central Publishing House, Sixth Edition 1988, Reprint 2000.

Reference Books:

R1. A course in IC Engines, V. M. Domkundwar, Dhanpat rai and sons, Paper back Edition, 2013.

R2. Fundamentals of Internal Combustion Engines,H.N.Gupta, PHI, 2^{nd} Edition, 2013.

R3. Internal Combustion Engines, K K Ramalingam, SciTech, 2^{nd} Edition, 2009.

R4. Fundamentals of IC Engines, J. B. Heywood, McGraw Hill, Paperback Edition, 1989.

R5. An Introduction to Combustion: Concepts and Applications, Stephen R Turns, TMH, 3rd Edition, 2012.

Open Sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering/
- http://www.myopencourses.com/discipline/mechanical-engineering

Mechanical Engineering Department

Subject Name: Power Plant Engineering (L:T:P-3:0:3)

Regulation Year: 2020-24

Course Code: MHE 23441 **Credit:** 5

Course Category: Program Elective **Contact hours:** 40

Recommended Pre-requisite: Thermodynamics, Fluid Mechanics, Heat Transfer

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Understand different types of Power Plants and site selection criteria for each of them.

CO2: Understand high pressure boilers and solve numerical on improved Rankine cycle.

CO3: Explain essential components of power plant and their effect on performances.

CO4: Understand different type steam turbines and their losses.

CO5: Understand knowledge of economic feasibility and its implications on power generating units.

THEORY PART (CONTENTS)

Unit 1: **(05 Hrs)**

Introduction

Schematic Diagrams and relative merits of Steam, Gas, Diesel and Hydro Power Plants, Factors affecting Selection of site, Nuclear Power Plants Classification, Types of Various Reactors with working of various Components. Present status of Power generation in India. Nuclear Power Plants in India, Waste Disposal of nuclear power plants, nuclear safety standards.

Unit 2: **(10 Hrs)**

High Pressure Boilers and Improved Rankine Cycle

Fossil fuel steam generators, classification, circulation in water tube boilers, Modern high pressure water tube boilers (both sub critical and super critical), Boiler mounting and accessories, Combustion equipment: air supply systems (Natural and Mechanical Draught Systems). Pulverized coal burning systems and Basics of Fluidized bed combustion, Feed water treatment (Necessity & general consideration only). Boiler performance calculations. Recent trends in Fluidized Bed Combustion Boiler.

Unit 3: (10 Hrs)

Essential Components of the Power Plants

Air Preheater, super heater, fuel treatment unit, Necessity of condensers, types of condensers, Dalton's law of partial pressures, condenser vacuum and vacuum efficiency, condenser efficiency, air pumps, capacity of air extraction pumps, cooling water requirements, Cooling towers. Equipment used for handling, storage, preparation, feeding of coal and water.

Unit 4: (10 Hrs)

Steam Turbines

Turbine types, Variation of Pressure and Velocity in different types of turbines, Simple impulse turbines, Flow through turbine blades and velocity diagram, Pressure-compounded impulse turbines and Velocity compounded impulse turbines. Turbine power and related calculations. Reaction turbines Flow through blades and velocity diagram, degrees of reaction, Parson's turbine, power and related calculations, Blade height calculations. Losses in steam turbines, Reheat factor & condition line, governing of turbines.

Unit 5: (08 Hrs)

Economics of Power Generation

Load duration, load curves, demand factor, average factor, capacity factor, reserve factor, diversity factor, plant use factor, construction of load duration curves, effect of variable load on power plant design and operation. Selection of power plant from site to waste disposal, life cycle costing, Fuel costs, Present worth concept. Project proposal preparation.

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)-*If any*

List of experiments: *(Minimum 10 experiments)*

1. Study of modern steam power plant.
2. Study about the Various Types of Fuel & Ash Handling Systems.
3. Study about different types of dust collectors and pulverized fuel burners.
4. Study about nuclear power plant.
5. Study of different types of steam turbines.
6. Study about different types of condensers and cooling towers.

7. Study about economics of power generation systems.
8. Study of gas power plant.
9. Study of combined steam & gas turbine power plant.
10. Testing of diesel fired water tube boiler based steam power plant

Text Books:

T1. "Power plant Engineering", P.K. Nag, TMH, 4^{th} Edition, 2014.

T2. "Power Plant Engineering", Arora and Domkundwar, Dhanpat Rai publications, 3rd, 2012

T3. "Modern Power Plant Engineering", Wesisman and Eckart, Prentice Hall of India, 4th, 2013.

Reference Books:

R1. "Power Plant Engineering", R.K. Rajput, Laxmi Publication, 4^{th} Edition, 2007.

R2. "Power Plant Engineering", P.C.Sharma, S. Kataria and sons, 5^{th} Edition, 2012.

R3. "Power Plant Engineering", M.E.I. Wakil, Tata McGraw Hill and Co.,3^{rd} Edition, 2010.

R4. "Power Plant Engineering", C Elanchezhian, I K International, Paper Back Edition, 2007.

Open Sources:

- NPTEL: www.nptel.ac.in/courses/112106133/15
- MIT open course ware: ocw.mit.edu › Courses
- IGNOU: www.ignou.ac.in/upload/Unit-1-58.pdf
- www.vssut.ac.in/lecture_notes/lecture1423005996.pdf

Subject Name: Industrial Operations Research (L:T:P- 3:0:3)

Regulation Year: 2020-24

Course Code: MHE 23439 **Credit: 5**

Course Category: Program Elective **Contact hours: 60 Hrs**

Recommended Pre-requisite:

- **Higher secondary level Probability and Statistics**

COURSE OUTCOMES:

CO 1: Formulate a real time situation into a mathematical model.

CO 2: Decide optimum locations and design layouts of plants and warehouses to minimise overall transportation cost.

CO 3: Optimize the system performance for production planning by applying the tools of forecasting, sequencing and scheduling.

CO 4: Minimize overall inventory cost through proper material handling and inventory control techniques.

CO 5: Perform network analysis for real life projects.

Course Details:

Unit 1: **(10 Hrs.)**

Introduction: Historical perspective of manufacturing management, Competitive priorities and operational strategy, Functional area strategy and Capability, Types of operation research models and its applications.

Linear programming problem formulation: graphical solution, simplex method, artificial variables techniques, two phases method, big-m method.

Nonlinear programming: One-dimensional minimization: Unimodal function- Elimination methods- Interpolation methods.

Unit 2: **(8 Hrs.)**

Transportation problem: Formulation - optimal solution, Unbalanced transportation problem - degeneracy, Assignment problem - formulation, optimal solution, variants of assignment problem travelling salesman problem.

Facility Design: Impact of Location of Facility on Cost and Revenue, Factors affecting Locations. Procedure and Models – Qualitative Models, Break-Even Analysis, Single Facility

Location Problem, Mini-max Location Problem, Gravity Location Problem, Process Layout, Product Layout, Group Layout, Fixed-position Layout.

Unit 3: **(8 Hrs.)**

Forecasting: Introduction, Quantitative Methods introduction, Time series and moving averages method, Exponential Smoothing method, Regression Analysis Method, Qualitative Methods.

Sequencing: Introduction, Flow shop sequencing: n jobs through two machines and n jobs through three machines, Job shop sequencing: two jobs through 'm' machines.

Unit 4: **(8 Hrs.)**

Inventory control: Introduction to Inventory and Materials Management, Statistical inventory control models, Dynamic lot sizing.

Production Planning: Aggregate production planning, Material Requirement Planning (MRP), Structure of MRP system, MRP Calculations. Capacity requirement planning, Rough-Cut capacity planning.

Unit 5: **(6 Hrs.)**

Networks and Project Management: Project Activity Networks, Precedence Diagrams, Project Network Models – PERT and CPM, Network Crashing, Project Feasibility, Appraisal and Selection.

Text Books:

T1: "*Production and Operations Management*", R. Panneerselvam, PHI publication.

T2: "*Industrial Engineering and Production Management*", Mertand T. Telsang, S. Chand publication.

T3: "*Industrial Engineering and Management*", O. P. Khanna, Dhanpat Rai Publications.

Reference Books:

R1. **"***Operations Research: methods and Problems*"**,** Arthur Yaspan, Lawrence Friedman and Maurice Sasieni, Literary Licensing publication.

R2. "*Modern Production/Operations Management*", Sarin Buffa, Wiley India Pvt. Ltd.

Open Sources:

- **https://nptel.ac.in/**
- **https://www.mooc.org/**

List of Experiments:

Experiment 1	Computation of linear programming using MS Excel / Minitab / any other statistical analysis packages.
Experiment 2	Computation of non-linear programming using MS Excel / Minitab / any other statistical analysis packages.
Experiment 3	Development of a plant location selection decision framework using MS excel / Minitab / any other statistical analysis packages.
Experiment 4	Layout design and line balancing.
Experiment 5	Forecasting using MS Excel / Minitab / any other statistical analysis packages.
Experiment 6	Development of scheduling plan.
Experiment 7	Development of MRP.
Experiment 8	Computation of EOQ and EBQ.
Experiment 9	CPM network analysis and crashing of networks.
Experiment 10	PERT network analysis.

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Subject Name: Refrigeration and Air-conditioning (L:T:P-3:1:3)

Regulation Year: 2020-24/2021-25

Course Code: MHE 23322 **Credit:** 5

Course Category: Program Core **Contact hours:** 40

Recommended Pre-requisite: Thermodynamics, Fluid Mechanics, Heat Transfer

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: analyze different refrigeration cycles and understand their applications.

CO2: explain the principle of multi compression and multi evaporation systems for better performance and specific applications.

CO3: understand the environmental impact of different refrigerants and their selection procedure

CO4: explain the concept of Psychrometric and applied Psychrometric.

CO5: understand thermal comfort, cooling load calculation and different air conditioning systems

THEORY PART (CONTENTS)

Unit 1: (8 Hrs.)

Air Refrigeration Cycles: Introduction, Unit of refrigeration, Coefficient of performance, Reversed Carnot Cycle, Temperature limitations, Maximum COP, Bell Coleman air cycle.

Vapour Compression System: Analysis of theoretical vapour compression cycle, Representation of cycle on T - S and p - h diagram, Simple saturation cycle, Wet vapour after compression. Sub-cooled cycle and super-heated cycle, Effect of suction and discharge pressure on performance, Actual vapour compression cycle.

Unit 2: (8 Hrs.)

Multi-stage compression and Multi-evaporator systems: Multistage compression with inter-cooling, Multi-evaporator system, Dual compression system.

Vapour Absorption System: Simple Ammonia absorption system, Improved absorption system, Analysis of vapour absorption system (Specifically analysis of column and rectifier), Lithium-bromide-water vapour absorption system, Electrolux/Three fluid system, comparison of absorption system with vapour compression system.

Unit 3: (8 Hrs.)

Refrigerants: Classification of refrigerants and its designation- Halocarbon compounds, Hydrocarbons, Inorganic compounds, Azeotropes, Properties of refrigerants, comparison of common refrigerants, uses of important refrigerants, Brines. Alternative refrigerants (Organic and inorganic compounds).

Unit 4: **(8 Hrs.)**

Psychrometrics: Properties of air-vapour mixture, Law of water vapour-air mixture, Enthalpy of moisture, Psychrometric chart, simple heating and cooling, Humidification, De-humidification, Mixing of Air. Thermodynamics of human body with environment, Requirement of comfort AC and comfort chart.

Unit 5: **(8 Hrs.)**

Air Conditioning System: Process in air conditioning: Summer and Winter air conditioning, Year-round air conditioning, Cooling load calculations.

Note:
At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)-*If any*

List of experiments: *(Minimum 10 experiments)*

1. Problem Solving on Air Refrigeration system.
2. Determination of COP on vapour compression system.
3. Problem Solving on vapour compression system.
4. Problem Solving on multi evaporation & multi compression system.
5. Determination of COP on vapour absorption system (Electrolux).
6. Performance test on Air conditioning test rig.
7. Performance analysis in an experimental cooling tower.
8. Determination of COP of an ice plant.
9. Analysis of Psychrometric processes using air conditioning test rig.
10. Problem Solving on summer & winter air-conditioning.

Text Books:

T1. "Refrigeration and Air conditioning" C.P. Arora, Tata McGraw Hill, 3rd Edition, 2008.

T2. "Refrigeration and Air conditioning" Manohar Prasad, New Age international publishers, 3rd Edition, 2015.

T3. "Refrigeration and Air Conditioning" W.F. Stoecker and J.W. Jones, McGraw-Hill Higher Education; 2nd edition, 2014.

Reference Books:

R1. "Refrigeration and Air Conditioning" R.C. Arora, PHI Publication, Paper Back Publication, 2010.

R2. "Refrigeration and Air Conditioning" S.C. Arora and S. Domkundwar, Dhanpat Rai & Sons, 1999.

R3. "Refrigeration and Air conditioning" P.L. Ballaney, Khanna Publishers, Paper Back Edition, 2003.

R4. "Refrigeration and Air conditioning Data book" Manohar Prasad, Paper Back Edition, 2014.

R5. "Refrigeration and Air conditioning" R.C. Jordand & G.B. Prister, Prentice Hall of India Publication, 2nd Edition, 1956.

R6. "Refrigeration and Air conditioning", R. S. Khurmi, J. K. Gupta, S. Chand Publication, Fifth edition, 2015.

R7. "Basic Refrigeration and Air Conditioning", by P N Ananthanarayan, Tata McGraw Hill, 4th edition, 2013.

Open Sources:

1. NPTEL: nptel.**ac**.in/courses/.../Ref
2. IGNOU: www.ignou.**ac**.in

Department of Mechanical Engineering

Subject Name: Mechanical Vibration (L:T:P-3:1:3)

Regulation Year: 2020 – 24

Course Code: MHE 23324 **Credit: 05**

Course Category: Program Core **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. Engineering Mechanics
2. Mechanics of Machines
3. Engineering Mathematics

COURSE OUTCOMES: After going through this course the student will be able to

CO1:	Modelling & analysis of single DoF systems for undamped, damped free vibrations, and forced vibrations.
CO2:	Vibration measuring instruments and concepts of critical speed
CO3:	Modelling & analysis of undamped vibrations of two DoF systems, modes of vibration, influence coefficient technique and vibration absorbers.
CO4:	Modeling and analysis of multi DoF systems, co-ordinate coupling, torsional vibration of two, three and multi rotor systems
CO5:	Analysis of continuous systems for various boundary conditions

Course Details:

(Theory)

<u>Unit-1</u>: Fundamentals and Undamped free vibration of single degree of freedom systems (08 Hrs.)

U1.1. Fundamentals of vibration, concepts on degrees of freedom, modelling of vibrating systems, equation of motion, evaluation of natural frequency using D'Alembert principle, Energy and Rayleigh's methods, equivalent systems.

U1.2. Brief history, types of vibration, simple harmonic motion, superposition principle.

Unit 2: Free and forced vibrations of damped single degree of freedom systems (12Hrs)

U2.1. Concept and types of damping, equation of motion, study of free vibration response of viscous damped systems for cases of under damping, critical damping and over damping, logarithmic decrement, loss factor.

Steady state solution for forced vibration system with viscous damping, forced vibration due to reciprocating & rotating unbalance mass and support motion, undamped whirling of shaft with single disc and concept on critical speed.

Vibration isolation and transmissibility, Vibration measuring instruments: vibrometer & accelerometer.

U2.2. Coulomb damping, structural damping, equivalent viscous damping, experimental evaluation of damping through free and forced vibration techniques.

Unit 3: Undamped vibration of two degrees of freedom systems (08 Hrs)

U3.1. Free vibration of spring coupled and mass coupled systems, mode shapes, semi definite systems, co-ordinate coupling, undamped dynamic vibration absorber, torsional vibration of two rotor systems.

U3.2 Torsional vibration absorber.

Unit 4: Introduction to multi degrees of freedom systems (06 Hrs)

U4.1. Generalized co-ordinates, matrix method, normal mode, influence coefficients, orthogonality of mode shapes, Holzer's method, Torsional vibration of three and multi rotor systems, Dunkerley's method

U4.2. Methods of matrix iteration, Transfer matrix method, and Stodola method

Unit 5: Continuous systems (06 Hrs)

U5.1. Transverse vibration of Euler beams: assumptions & derivation of equation of motion for various boundary conditions, characteristics equations and mode shapes.

U5.2. Vibration of strings, longitudinal and torsional vibration of rods.

(Practical/Laboratory)

(Any 6 Experiments)

Experiment no.1: Determination of damped and undamped natural frequencies of torsional vibration of a single rotor system.

Experiment no. 2: Determination of damped and undamped natural frequencies of a two rotor system.

Experiment no. 3: Evaluation of natural frequency of transverse vibration of a beam using Dunkerley's method.

Experiment no.4: Study the response of forced damped vibration of a simply supported beam with concentrated loads.

Experiment no. 5: Study of whirling phenomena of a rotating shaft and to determine its critical speed.

Experiment no. 6: Evaluation of damping factor of MS, Al, Brass and Copper cantilever beam specimens using log-decrement method.

Experiment no. 7: Study the performance characteristics of a tuned vibration absorber.

Books:

Text Books:

T1. "Mechanical Vibrations" S.S. Rao, Pearson Education Inc, 6th Edition, 2017.

T2. "Mechanical Vibrations", V.P. Singh, Dhanpat Rai & company Pvt. Ltd. 3rd Edition, 2006.

T3. "Theory of vibration with Applications", W.T. Thomson and Marie Dillon Dahleh, Pearson Education, 5th Edition, 2014.

Reference Books:

R1. "Mechanical Vibrations" S. Graham Kelly, Schaum's outline series, Tata McGraw Hill, Special Indian Edition., 2007.

R2. "Elements of vibration Analysis", Leonard Meirovitch, Tata McGraw Hill, Special Indian Edition, 2007.

R3. "Mechanical vibrations", J. S. Mehta and A.S. Kailey, S. Chand & Company, 1st Edition, 2012.

R4. "Theory and application of Mechanical Vibrations", Dilip Kumar Adhwarjee, Laxmi publications (p) Ltd, 1st Edition, 2016.

R5. "Introductory Course on theory and Practice of Mechanical Vibrations", J.S. Rao & K.Gupta, New Age International Publication, New Delhi, 2nd Edition, 2014.

Open sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering/
- http://www.myopencourses.com/discipline/mechanical-engineering

Department of Mechanical Engineering

Subject Name: Value Engineering (L:T:E – 3:0:0)

Machines Regulation Year: 2020-24/2021-25

Course Code: MHE 21512 **Credit: 03**

Course Category: Open Elective **Contact hours: 40 hrs**

Recommended Pre-requisite:

1. **Production Technology**
2. **Organizational Behaviour**
3. **Mathematics – I , II ,III**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Discuss the concepts of value engineering, identify the advantages, applications.

CO2: Discuss various phases of value engineering. Analyze the function, approach of function and evaluation of function. Determine the worth and value.

CO3: Discuss queuing theory.

CO4: Appraise the value engineering operation in maintenance and repair activities.

CO5: Create the value engineering team and discuss the value engineering case studies.

Course Details:

Unit1: Introduction and organization **(10 Hrs.)**

Value engineering concepts, advantages, applications, problem recognition, and role in productivity, criteria for comparison, element of choice.Level of value engineering in the organization, size and skill of VE staff, small plant, VE activity, unique and quantitative evaluation of ideas.

Unit2: Kinematics of Cams, Gears and Gear Trains **(11 Hrs.)**

Introduction, orientation, information phase, speculation phase, analysis phase. Selection and Evaluation of value engineering Projects, Project selection, methods selection, value standards, application of value engineering methodology. Anatomy of the function, use esteem and exchange values, basic vs. secondary vs. unnecessary functions. Approach of function, Evaluation of function, determining function, classifying function, evaluation of costs, evaluation of worth, determining worth,evaluation of value.

Unit3: Dynamic Force Analysis **(8 Hrs.)**

Selecting products and operation for value engineering action, value engineering programmes, determining and evaluating function(s) assigning rupee equivalents, developing alternate means to required functions, decision making for optimum alternative, use of decision matrix, queuing theory and Monte Carlo method make or buy, measuring profits, reporting results, Follow up, Use of advanced

Unit4: Balancing and Vibration **(6 Hrs.)**

Value engineering operation in maintenance and repair activities, value engineering in non hardware projects. Initiating a value engineering programme Introduction, training plan, career development for value engineering specialties.

Unit5: Mechanisms for Control & Gyroscope **(5 Hrs.)**

Value engineering team, co-coordinator, designer, different services, definitions, construction management contracts, value engineering case studies.

Text Books:

1. Lawrence D. Miles, Techniques of Value Analysis and Engineering, MCGraw-Hill Book Company.
2. John H. Fasal, Practical Value analysis Methods, Hayden Book Company.
3. Donald E. Parker, Value Engineering Theory, Lawrence D. Miles Value Foundation.
4. Fallon, Carlos, Value Analysis, Lawrence D. Miles Value Foundation.
5. Gage E.L., Value Analysis, McGraw-Hill Book Company.

Reference Books:

1) Michael LeBoeuf, How to Motivate People, Sidgwick and Jackson.
2) S. Choudhury, Project Management, Tata McGraw-Hill Publishing Company Ltd.
3) B. D. Perry, Commonalities for a Strong Value Engineering Programme, Value World, Oct/Nov/Dec., 1989.
4) R.V. Gopalkrishnan, Practicing Value Management, Value World, Apr/May/June, 1990.
5) Ginger Willingham, CVS, Value Analysis: Universal Applicability, Limited Usage, Value World, July/Aug/Sept., 1990.

Open Sources:

https://nptel.ac.in

https://ocw.mit.edu/courses/mechanical-engineering/

https://www.classcentral.com/provider/swayam

https://www.coursera.org/in

https://www.mooc.org/

Department of Mechanical Engineering

Subject Name: Vehicle Dynamics (L:T:P-3:0:0)

Regulation Year: 2020 – 24

Course Code: MHE 21514 **Credit: 03**

Course Category: Open Elective **Contact hours: 40 hrs**

Recommended Pre-requisite:

1. **Engineering Mechanics**
2. **Mechanics of Machines**
3. **Physics**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Understand the fundamentals Vehicle's performance characteristics

CO2: Understand Aerodynamics and Tire Mechanics involved.

CO3: Understand Suspension systems.

CO4: Understand Steering systems.

CO5: Understand Rollover and Motorcycle Dynamics.

Course Details:

Unit1: Performance Characteristics of Vehicle **(06 Hrs.)**

Performance Characteristics of Vehicle: SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, power limited and traction limited acceleration, braking performance, Brake proportioning, braking efficiency.

Unit2: Aerodynamics and Tire Mechanics **(12 Hrs.)**

Aerodynamics: Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids.

Tire Mechanics: Tire Construction, Size and Load Rating, Terminology and Axis System, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Slip, Skid, Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tire Formula.

Unit3: Suspension Systems **(07 Hrs.)**

Suspensions: Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension

Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points. Controllable Suspension Elements: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions

Unit4: Steering Systems **(07 Hrs.)**

The Steering System: The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steadystate model), Understeer and Oversteer, Effect of Tire Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3 DOF unsteady model), Steady-State and Transient Handling of Articulated Vehicles.

Unit5: Rollover and Motorcycle Dynamics **(08 Hrs.)**

Rollover: Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover.

Motorcycle Dynamics: Kinematic structure of motorcycle, geometry of motorcycles, importance of trail, Resistance forces acting on motorcycle (tyre rolling resistance, aerodynamic resistance forces, resistant force caused by slope), Location & height of motor cycle's centre of gravity (C.G), Moments of inertia on Motorcycle. Introduction to Front & Rear suspensions of Motorcycle.

Text Books:

1. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012.
2. Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.
3. Rajesh Rajamani, Vehicle Dynamics & control, Springer.
4. R.V. Dukkipati, Vehicle dynamics, Narsova Publications.

Reference Books:

1. Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE.
2. Garrett T K, Newton K and Steeds W, "Motor Vehicle", Butter Worths & Co., Publishers Ltd., New Delhi, 2001.
3. Heinz Heister, "Vehicle and Engine Technology", SAE Second Edition, 1999.
4. Vittore Cossalter, Motorcycle Dynamics, 2nd Edition, Publisher: LULU.com
5. R N Jazar, Vehicle Dynamics: Theory and Application, Springer.

Open Sources:

1. NPTEL Video course on Vehicle Dynamics:

   https://nptel.ac.in/courses/107/106/107106080/

Mechanical Engineering Department

Subject Name: Total Quality Management (L:T:P-3:0:0)

Regulation Year: 2020-2024/2021-2025

Course Code: MHE 21516 **Credit: 03**

Course Category: Open Elective **Contact hours: 42**

COURSE OUTCOMES: After going through this course the student will be able to

CO1 Analyse basic concepts of quality improvement and Describe the DMAIC process (define, measure, analyse, improve, and control).

CO2 Design, use, and interpret control charts for variables and attributes and measure capability of system

CO3 Apply TQM tools and techniques to various manufacturing and services processes.

CO4 Design quality into the product.

CO5 Appraise international/national Quality awards

CO6 Work collaboratively in teams to undertake laboratory exercises, analysing and discussing the outcomes and communicate those via professional reports.

Course Details:

Unit 1: **(8 hrs)**

Title: Quality Improvement in the Modern Manufacturing Environment

Why quality, Quality and its Evolution, Dimensions of product and service quality, TQM and its Framework, Contributions of Deming, Juran and Crosby, Hindrances of TQM, Costs of quality, Quality Circle, DMAIC process, Quality Assurance and Quality Control, Continuous process improvement, PDCA cycle.

Unit 2: **(10 hrs)**

Title: Methods and Philosophy of Statistical Process Control and Analysis of Capability

Control Chart fundamentals, Control chart for Variables, Control Chart for attributes, Acceptance Sampling, Process Capability

Unit 3: **(8 hrs)**

Title: Quality Management Tools and Techniques

Quality functions development (QFD) Voice of customer, House of quality (HOQ), QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, Six Sigma, Bench marking and POKA YOKE.

Unit 4: **(8 hrs)**

Title: Quality Engineering

Introduction to Taguchi techniques, loss function, Parameter and tolerance design, Signal to noise ratio.

Unit 5: **(8 hrs)**

Title: Quality Systems

Need for ISO 9000, ISO 9001-2008, Quality System, Elements, Documentation, Quality Auditing, QS 9000, ISO 14000, Concepts, Requirements and Benefits, TQM Implementation in manufacturing and service sectors.

Subject Text

[T1] D. H. Besterfield et al., Total Quality Management, Pearson, 3rd ED., 2012
[T2] D. L., Goetsch, & S. B. Davis, Quality management for organizational excellence. Pearson, 8th ED., 2016
[T3] D. C. Montgomery, Introduction to Statistical Quality Control, John Wiley & Sons, Inc., 6th ED., 2009

References

[R1] A. Mitra, Fundamentals of Quality Control and Improvement, John Wiley & Sons, Inc., 4th ED., 2016

[R2] V.K. Omachonu and J.E. Ross, Principles of Total Quality, CRC Press, 3rd ED., 2004.

Open Sources:

1. NPTEL: nptel.ac.in/courses/.../Ref

YouTube Clips

The following YouTube Clips should help augment your weekly lectures.

Statistical Process Control at:

https://www.youtube.com/watch?v=e5g2NmIUdck

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

Process Control at Honda case at:

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

Reliability Concepts at:

https://www.youtube.com/watch?v=eckn-f2R_LQ

Assessment of System Reliability at:

https://www.youtube.com/watch?v=GeMCF3s5EDk

Mechanical Engineering Department

Subject Name: Gas Dynamic and Propulsion (L:T:P-3:0:3)

Regulation Year: 2020-24/2021-25

Course Code: MHE 23410 **Credit:** 5

Course Category: Program Elective **Contact hours:** 40

Recommended Pre-requisite: Basic Thermodynamics, Internal Combustion Engine

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Understand the one - dimensional steady compressible fluid flow

CO2: Calculate the adiabatic and isentropic properties in various regions of flow

CO3: Calculate the adiabatic and isentropic properties in various conditions of flows during friction and heat transfer

CO4: Analyze the flow properties on shock waves in various flow regions

CO5: Apply the gas dynamics principles in the jet and space propulsion. Interpret the differences in Pressure, Temperature and Mach number in various regions of fluid flow

THEORY PART (CONTENTS)

Unit 1: **(6 Hrs.)**

Basic concepts and isentropic flows

Energy and momentum equations of compressible fluid flows – Stagnation states, Mach waves and Mach cone – Effect of Mach number on compressibility, Isentropic flow through variable ducts – Nozzle and Diffusers.

Unit2: **(6 Hrs.)**

Flow through ducts

Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties, Generalized gas dynamics, Use of tables and charts.

Unit 3: **(8 Hrs.)**

Normal and oblique shocks

Governing equations – Variation of flow parameters across the normal and oblique shocks, Prandtl – Meyer relations – Applications.

Unit 4: **(10 Hrs.)**

Jet propulsion

Theory of jet propulsion – Thrust equation – Thrust power and propulsive efficiency – Operating principle, Cycle analysis and use of stagnation state performance of ram jet, turbojet, turbofan and turbo prop engines

Unit 5: **(10 Hrs.)**

Space propulsion

Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion, Performance study – Staging – Terminal and characteristic velocity – Applications – space flights.

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)-*If any*

List of experiments: *(Minimum 10 experiments)*

1. CFD analysis of steady and incompressible gas flow through nozzle.
2. CFD analysis of steady and incompressible gas flow through diffuser.
3. Study of Mach number on compressibility of flow.
4. CFD analysis of steady and compressible gas flow through nozzle.
5. CFD analysis of steady and compressible gas flow through diffuser.
6. CFD analysis of unsteady and incompressible flow through rocket nozzle.
7. CFD analysis of unsteady and compressible flow through rocket nozzle.
8. Prepare a case study related to shock waves.
9. Perform a comprehensive review work on the history of jet propulsion.
10. Perform a comprehensive review work on the history of space missions.

Text Books:

T1: Anderson, J.D., Modern Compressible flow, McGraw Hill, 3rd Edition, 2003

T2: H. Cohen, G.E.C. Rogers and Saravanamutto, Gas Turbine Theory, Longman Group Ltd., 1980.

T3: S.M. Yahya, fundamentals of Compressible Flow, New Age International (P) Limited, New Delhi, 1996.

Reference Books:

R1. P. Hill and C. Peterson, Mechanics and Thermodynamics of Propulsion, Addison – Wesley Publishing company, 1992.

R2. N.J. Zucrow, Aircraft and Missile Propulsion, vol.1 & II, John Wiley, 1975

R3. N.J. Zucrow, Principles of Jet Propulsion and Gas Turbines, John Wiley, New York, 1970

R4. G.P. Sutton, Rocket Propulsion Elements, John wiley, 1986, New York.

R5. A.H. Shapiro, Dynamics and Thermodynamics of Compressible fluid Flow, , John wiley, 1953, New York.

Open Sources:

- NPTEL: https://nptel.ac.in/courses/112/106/112106166/
- MIT Open Courseware: https://ocw.mit.edu/courses/aeronautics-and-astronautics/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/thermo-propulsion/

Mechanical Engineering Department

Subject Name: Additive Manufacturing (L:T:P-3:0:3)

Regulation Year: 2020-2024

Course Code: MHE 23419 **Credit: 05**

Course Category: Program Elective **Contact hours: 60**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Fundamentals of Additive Manufacturing

CO2: Materials for Additive Manufacturing

CO3: Various additive Technology

CO4: Mathematical modeling for Additive manufacturing

CO5: Process Planning for additive Manufacturing

Course Details:

Unit1: Introduction to Additive Manufacturing (AM) (8 Hrs)

General overview Introduction to reverse engineering Traditional manufacturing vis AM Computer aided design (CAD) and manufacturing (CAM) and AM Different AM processes and relevant process physics AM process chain Application level: Direct processes – Rapid Prototyping, Rapid Tooling. Rapid Manufacturing; Indirect Processes - Indirect Prototyping. Indirect Tooling, Indirect Manufacturing

Unit2: Material Science for AM (8 Hrs)

Discussion on different materials used Use of multiple materials, multifunctional and graded materials in AM Role of solidification rate Evolution of non-equilibrium structure Structure property relationship Grain structure and microstructure

Unit 3: (8 Hrs)

AM Technologies: Powder-based AM processes involving sintering and melting (selective laser sintering, shaping, electron beam melting. involvement). Printing processes (drop!et based 3D Solid-based AM processes - extrusion based fused deposition modeling object Stereolithography Micro- and nano-additive.

Unit4: (8 Hrs)

Mathematical Models for AM: Transport phenomena models: temperature, fluid flow and composition, buoyancy driven tension driven free surface flow pool. Case studies Numerical modeling of AM surface, Powder bed melting based process. Droplet based printing process, Residual stress, part fabrication time, cost, optimal orientation and optimal, Defect in AM and role of transport.

Unit5: **(8 Hrs)**

Process selection planning and control for AM: Selection of AM technologies using decision methods, Additive manufacturing process plan: strategies and post processing. Monitoring and control of defects.

Text Books:

T1:- Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.Kasana, H.S., Introductory Operation Research: Theory and Applications, Springer Verlag (2005).

T2**: -** Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011

Reference Books:

R1. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642-28539-8

R2. L. Lu, J. Fuh and Y.-S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press, 200 I

R3. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.

R4. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 20 10

List of Experiments

Experiment No 1: To simulate the anatomy of 3D Printer, to get in-depth knowledge of mechatronics of 3D printer.

Experiment No 2: To simulate the construction of cartesian 3D printer and to get in-depth knowledge of mechatronics of polar 3D printer

Experiment No: 3: To simulate the construction of polar 3D printer and to get in-depth knowledge of mechatronics of polar 3D printer.

Experiment No 4: To simulate the construction of delta 3D printer and to get in-depth knowledge of mechatronics of delta 3D printer.

Experiment No 5: To simulate the stereolithography (SLA) process.

Experiment No: 6: To simulate the Fused Deposition Modelling (FDM) process.

Experiment No 7:_Simulation of Selective Laser Sintering(SLS) process for non-metallic materials.

Experiment No 8: Simulation of Selective Laser Sintering(SLS) process for non-metallic materials.

Experiment No: 9: To simulate Laminated Object Manufacturing (LOM) process.

Experiment No 10:_Simulation of Powder Binding / Jetting Process.

Experiment No 11:_To simulate the post processing of 3d printed parts via:

Experiment No 12:_To simulate the Pre Processing for 3D printing.

Open Sources:

https://3dp-dei.vlabs.ac.in/

https://nptel.ac.in/courses/112/103/112103306/

Department of Mechanical Engineering

Subject Name: Finite Element Analysis in Engineering (L:T:P-3:0:3)

Regulation Year: 2020 – 24

Course Code: MHE 23421 **Credit: 05**

Course Category: Program Elective **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. Engineering Mechanics
2. Engineering Mathematics
3. Heat and Mass Transfer
4. Mechanics of Solids
5. Fluid Mechanics

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Explain basic principles involved in the FEM.

CO2: Analyze Truss structures and Flexure Elements.

CO3: Select elements for FEM analysis and will be able to use FEM in Heat Transfer analysis

CO4: Analyze fluid flow using FEM

CO5: Use FEM in solid Mechanics analysis.

Course Details:

Unit 1: Basics of Finite Element Method **(7 Hrs.)**

Unit 1.1: Introduction, General Procedure of Finite Element Analysis, Stifness Matrices, Spring and Bar elements, Strain Energy, Castigiliano's First Theorem, Minimum Potential Energy,

Unit 1.2: Fundamental concepts and matrix algebra

Unit 2: Truss Structures and Flexure Elements **(11 Hrs.)**

Unit 2.1:
Truss Structures (Direct Stiffness Method): Nodal Equillibrium Equation, Element transformation, Global Stifness Matrix, Boundary Conditions, Constraint Forces, Element strain and stress
Flexure Elements: Elementary Beam Theory, Flexure Element, Flexure Element Stiffness Matrix, Element Load Vector, Work equivalence for Distributed Load, Flexure Element with Axial Load
Unit 2.2: Three Dimensional Truss, General 3 D Beam Element, Method of Weighted Residuals, Galerkin Finite Element Method.

Unit 3: Element Formulation and FEM Application in Heat Transfer (10 Hrs.)

Unit 3.1:

Element Formulation: Introduction, Compatibility and Completeness Requirement, One Dimensional Elements, Geometric Isotropy, Triangular Elements, Rectangular Elements, Three Dimensional Elements

Heat Transfer: Introduction, One dimensional Conduction: Quadratic Element, One Dimensional Conduction with Convection, Heat Transfer in Two Dimensions, Heat Transfer with Mass Transport

Unit 3.2: Isoparametric Formulation, Axisymmetric Elements, Numerical Integration: Gaussian Quadrature, Heat Transfer in 3D, Time Dependent Heat Transfer.

Unit 4: FEM Application in Fluid Flow (6 Hrs.)

Unit 4.1:

Introduction, Governing Equations for Incompressible Flow, The steam function in Two-Dimensional Flow, The Velocity Potential Function in 2 D Flow.

Unit 4.2: Incompressible Viscous flow.

Unit 5: FEM Application in Solid Mechanics (6 Hrs.)

Unit 5.1: Introduction, Plane stress, Plane strain: Rectangular element, Isoparametric formulation of the Plane Quadriletral element, Axisymmetric Stress Analysis.

Unit 5.2: 3 D stress elements, Stress stress computation, Torsion, Structural dynamics.

Text Books:

T1:- "Fundamentls of Finite Element Analysis", David Hutton, McGraw-Hill Publication , 1st Edition, 2004

T2: "Finite Element Analysis", S. S. Bhavikatti, New Age Publication, 3rd Edition, 2015.

T3: "A Text Book of Finite Element Analysis", P.Seshu, PHI Publication, 1st Edition, 2003

2003

Reference Books:

R1. "Introduction to Finite Element in Engineering", T.R .Chandrupatta and A.D.Belegundu, Pearson Education India, 4th Edition, 2015.

R2. "An Introduction to the Finite Element Method", J.N. Reddy, Tata McGraw-Hill, 4th Edition, 2020.

R3. "The finite element method", T. J. R. Hughes, PRENTICE-HALL, INC, Englewood Cliffs, New Jersey.

R4. " Practical Finite Element Analysis", N.S. Gokhale, Finite to Infinite Publication, 2008 Edition

Open Sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering
- http://www.myopencourses.com/discipline/mechanical-engineering

(Sessional/Practical)

Experiment Details *(any 6 Experiments using ANSYS):*

Experiment 1	FEM analysis of Bars and Trusses
Experiment 2	FEM analysis of Beams and Frames
Experiment 3	Case study on Two-Dimensional Elasticity using FEM
Experiment 4	FEM analysis of Plate and Shell
Experiment 5	Case study on Three-Dimensional Elasticity using FEM
Experiment 6	FEM analysis of Structural Vibration and Dynamics
Experiment 7	Thermal Analysis using FEM
Experiment 8	Fluid Flow Analysis using FEM

Open Sources/Virtual lab:

https://www.youtube.com/user/ANSYSHowToVideos

http://www.mece.ualberta.ca/tutorials/ansys/

https://vlab.amrita.edu/?sub=62&brch=271

Department of Mechanical Engineering

Subject Name: **Computer Integrated Manufacturing** (L:T:P-3:0:3)

Regulation Year: 2020-24

Course Code: MHE 23423 **Credit: 05**

Course Category: Program Elective **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. **Manufacturing Process**
2. **CNC machine**
3. **Robotics**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Understand the fundamentals of manufacturing and automation

CO2: Understand the concepts of industrial robotics and robotic programming & languages

CO3: Understand the programmable logic controllers

CO4: Understand the basics of manufacturing systems

CO5: Understand the fundamentals of flexible manufacturing system

Course Details:

Unit1: **(09 Hrs.)**

Unit 1.1: Fundamentals of Manufacturing and Automation: Production systems, automation principles and its strategies; Manufacturing industries; Types of production function in manufacturing; Automation principles and strategies, elements of automated system, automation functions and level of automation; product/production relationship.

Unit 1.2: Production concept and mathematical models for production rate, capacity, utilization and availability; Cost-benefit analysis.

Unit2: **(09Hrs.)**

Unit 2.1: Computer Integrated Manufacturing: Basics of product design, CAD/CAM, Concurrent engineering, CAPP and CIM. Industrial Robotics: Robot anatomy, control systems, end effectors, sensors and actuators; fundamentals of NC technology, CNC, DNC, NC part programming; Robotic programming, Robotic languages.
Unit 2.2: work cell control, Robot cleft design, types of robot application, processing operations.

Unit3: (7 Hrs.)

Unit 3.1: Programmable Logic controllers: Parts of PLC, Operation and application of PLC, Fundamentals of Net workings; Material Handling and automated storage and retrieval systems, automatic data capture, identification methods, bar code and other technologies.
Unit 3.2: identification methods, bar code and other technologies.

Unit4: (8 Hrs.)

Unit 4.1: Introduction to manufacturing systems: Group Technology and cellular manufacturing, Part families, Part classification and coding, Production flow analysis, Machine cell design.
Unit 4.2: Applications and Benefits of Group Technology.

Unit5: (7 Hrs.)

Unit 5.1: Flexible Manufacturing system: Basics of FMS, components of FMS, FMS planning and Implementation, flexibility, quantitative analysis of flexibility, application and benefits of FMS.

Unit 5.2: Computer Aided Quality Control: objectives of CAQC, QC and CIM, CMM and Flexible Inspection systems.

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover, Pearson Publication
2. Automation, Production systems & Computer Integrated Manufacturing, M.P Groover, PHI.
3. CAD/CAM/CIM, P.Radhakrishnan, S.Subramanyam and V.Raju, New Age International
4. Flexible Manufacturing Systems in Practice, J Talavage and R.G. Hannam, Marcell Decker

Reference Books:

1. CAD/CAM Theory and Practice, Zeid and Subramanian, TMH Publication
2. CAD/CAM Theory and Concepts, K. Sareen and C. Grewal, S Chand publication
3. Computer Aided Design and Manufacturing, L. Narayan, M. Rao and S. Sarkar, PHI.
4. Principles of Computer Integrated Manufacturing, S.K.Vajpayee, PHI
5. Computer Integrated Manufacturing, J.A.Rehg and H.W.Kraebber, Prentice Hall

Open Sources:

https://nptel.ac.in

https://nptel.ac.in/courses/112/104/112104289/

https://ocw.mit.edu/courses/mechanical-engineering/

https://www.classcentral.com/provider/swayam

https://www.coursera.org/in

https://www.mooc.org/

Experiment Details: ***(Minimum 10 experiments)***

Experiment 1: Study of robot anatomy

Experiment 2: Study of various robot programming techniques

Experiment 3: Write a program to perform the desired task

Experiment 4: Study of automated material handling system.

Experiment 5: Design a work cell to perform loading and unloading.

Experiment 6: Study of various sensors used in factory.

Experiment 7: Study & use some comparative integrated inspection systems

CMM
Optical Instruments
Laser Interfero meter
Surface imaging & roughness
Digital linear measurement instruments

Experiment 8: Use of 3D software for design

Press tools

Plastic component moulds

Fixtures

Experiment 9: Use of MIG, TIG & other special welding techniques to prepare different types of joints

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Experiment 10: Study of different techniques used for inspection of welds
Experiment 11: Study of micro & macro structure of welds

Open Sources/Virtual lab:

http://mm-nitk.vlabs.ac.in/#

http://vlabs.iitkgp.ac.in/mr/#

http://mdmv-nitk.vlabs.ac.in/#

https://dom-nitk.vlabs.ac.in/

Subject Name: Introduction to Cryogenics Engineering (L:T:P-3:0:3)

Regulation Year: 2020-24/2021-25

Course Code: MHE 23425 **Credit:** 5

Course Category: Program Elective **Contact hours:** 35

Recommended Pre-requisite: Engineering Mathematics, Thermodynamics, heat transfer, Refrigeration

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Explain about the Properties of matter at low temperatures.

CO2: Describe the cryogenic systems.

CO3: Understand Regenerative refrigeration cycles

CO4: Illustrate the real time applications Purification and separation of gas mixtures.

CO5: Relate the skill of design of superconducting magnates.

THEORY PART (CONTENTS)

Unit 1: **(8 Hrs)**

Properties of matter at low temperatures: mechanical, thermal, electrical and magnetic; Properties of fluids: equations of state, transport properties; temperature and pressure dependence; Review of relevant thermodynamic principles: engines, refrigerators, heat pumps; efficiency & COP; Carnot cycle.

Unit 2: **(6 Hrs)**

Thermal equipment for cryogenic systems - compressors, expanders, valves, heat exchangers; representation of processes on p-v, T-s and p-h charts, Refrigeration and liquefaction cycles: Linde, Claude, Kapitza cycles; Representation on T-s chart; Calculation of COP and liquid yield; Liquefaction of hydrogen and helium

Unit 3: **(6 Hrs)**

Regenerative refrigeration cycles - Stirling, G M, pulse tube; calculation of COP, Cryogenic fuels - LNG and liquid hydrogen: liquefaction, storage, transportation and utilisation.

Unit 4: **(8 Hrs)**

Principles of vapour liquid equilibria, x-y, p-x,y and T-x,y charts; adsorption isotherms; Purification and separation of gas mixtures: purification by TSA and PSA processes, distillation, air separation; design of distillation column using Macabe-Thiele method, Cryogenic insulation and design of storage vessels - thermal and mechanical design.

Unit 5: (7 Hrs)

Superconductivity and superconducting magnets; design of superconducting solenoid magnets; thin-film superconductivity, Application of cryogenic systems, industrial gases and superconducting devices

Note:
At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)-*If any*

List of experiments: *(Minimum 10 experiments)*

1. Study of high vacuum pumping station - rotary and diffusion pumps, pump operation and sequencing.
2. Measurement of pumping speed of high vacuum pumping station; plot of pumping speed against vacuum (pressure) attained.
3. Study of refrigerator cryopump; measurement of pumping speed.
4. Study of vacuum brazing furnace; brazing of copper, brass and stainless steel components.
5. Study of helium compressor used in GM refrigerators; measurement of flow rate and comparison with specifications.
6. Study of GM cycle cold head; measurement of refrigeration output.
7. Study of membrane type nitrogen gas generator; measurement of flow rate as a function of purity achieved.
8. Study of pulse tube refrigerator; measurement of COP
9. Study of a liquid nitrogen generator - working out mass and energy balance.
10. Field study of a commercial air separation plant

Text Books:

T1: Fundamentals of Cryogenic Engineering by Mamata Mukhopadhyay, PHI publisher.

T2: Cryogenics: A Textbook by S. S. Thipse, Alpha Science International Ltd publisher

T3: Cryogenic Engineering by Thomas Flynn, CRC Press publisher

Reference Books:

R1. Cryogenic Process Engineering, by Timmerhaus Thomas and M. Flynn, Plenum Press, Nework

R2. Cryogenic Systems by Randall F. Barron, McGraw-Hill Inc., US

Open Sources:

- **NPTEL:** https://nptel.ac.in/courses/112/101/112101004/

Subject Name: Product Design and Manufacturing (L:T:P-3:0:3)

Regulation Year: 2020-24

Course Code: MHE 23427 **Credit: 5**

Course Category: Program Elective **Contact hours: 60 Hrs.**

Recommended Pre-requisite:

1. Basic Manufacturing Processes
2. Metal Cutting and Machine Tools
3. Material Science

COURSE OUTCOMES: After going through this course the student will be able to

CO1 understand the principles of product design.

CO2 analyze the product lifecycle.

CO3 explain material selection process.

CO4 explain manufacturing process selection.

CO5 understand the concepts of recovery and recycling.

Course Details:

Unit1: Product Design and Development **(8 Hrs.)**

Introduction to product design, product design practice and industry, strength consideration in product design, optimization in design, economic factors influencing design, value engineering and product design.

Unit2: Product Lifecycle Analysis **(8 Hrs.)**

The Product Lifecycle Model, Product Planning, Understanding Customer Needs, Product Teams, Managing Product Design and Development, Supply Chain Analysis, Sales, Distribution and Presales Support, Managing and Responding to Disruption, Life Cycle Cost, P&L Management and ROI

Unit3: Material Selection **(8 Hrs.)**

Introduction to Materials Selection in the Design Process, Performance indices, Optimal materials selection without shape, Introduction to computer based materials selectors, Materials selection under multiple constraints, Shape factors for different types of loading, Optimal materials selection with shape.

Unit4: Manufacturing Process Selection (8 Hrs.)

Producibility requirements in the Design of machine Components, Forging Design, pressed components Design, Casting Design, and Design for Machining Ease, The Role of Process Engineer, Ease of Location Casting and Special Casting.

Unit5: Recovery and Recycling (8 Hrs.)

Selection of Recovery and Recycling process, Introduction to Sustainable Resource Management(SRM), Collection Systems, History of Solid Waste Management.

Text Books:

T1. "Product Design and Manufacturing", A.K. CHITALE and R.C. GUPTA, PHI Learning Private Limited, 5th Edition, 2011.

T2. "Manufacturing Technology Vol I", P. N. Rao, Tata McGraw Hill Education Private Limited, 4th Edition, 2014

T3. Product Design Techniques in Reverse Engineering and New Product Development, Kevin Otto & Kristin Wood, Pearson Education (LPE), 2001.

T4. Product Design and Development, Karl t. Ulrich, steven Eppinger, TATA McGraw-Hill- 3rd Edition, 2003.

Reference Books:

R1. "Processes and Materials of Manufacture", A. Lindberg, PHI / Pearson Education (India), 4th Edition, 2006.

R2. "Materials and processes in manufacturing", E. Paul Degarmo, J T Black, Ronald A Kohser, John wiley and sons, 8th Edition, 1999.

R3. M. F. Ashby, Materials Selection in Mechanical Design, Elsevier Publication, 2005.

Open Sources:

https://nptel.ac.in
https://ocw.mit.edu/courses/mechanical-engineering/
https://www.classcentral.com/provider/swayam
https://www.coursera.org/in
https://www.mooc.org/

Experiment Details:

Experiment 1	**Product Design and Development**
Experiment 2	**Product Lifecycle Analysis**
Experiment 3	**Material Selection**
Experiment 4	**Manufacturing Process Selection**
Experiment 5	**Recovery and Recycling**

Capstone Project: Student have to submit a product in final examination based on the five experiments.

Open Sources/Virtual lab:
https://nptel.ac.in

https://www.youtube.com

Department of Mechanical Engineering

Subject Name: Introduction to Mechatronics (L:T:P-3:0:3)

Regulation Year: 2020 – 24

Course Code: MHE 23429 **Credit: 05**

Course Category: Program Elective **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. **Engineering Mechanics**
2. **Basic Electronics Engineering**
3. **Basic Electrical Engineering**
4. **Engineering Mathematics**
5. **Theory of Machines**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Explain basic concepts of Mechatronics.

CO2: Identify sensors used in Mechatronics and will be able to condition the signals.

CO3: Select actuators used in different applications.

CO4: Analyze microprocessor systems

CO5: Design the system models mathematically.

Course Details:

Unit 1: Basics of Mechatronics **(3 Hrs.)**

Unit 1.1:

Introduction, Design Process, Systems, Measurement systems, Control systems, Programmable logic controller

Unit 1.2:

Mechatronic systems: digital camera and autofocus, engine management systems, MEMS

Unit 2: Sensors and Signal Conditioning **(8 Hrs.)**

Unit 2.1:

Sensors and Transducers: Performance Terminology, Dispalcement, position and proximity, Velocity and motion, force, fluid pressure, liquid flow, temperature, light sensors, selection of sensors, inputing data by switches.

Signal Conditioning: OPAM, protection, filtering, wheatstone bridge, power transfer.

Unit 2.2:

Digital signals, Analogue to Digital, Digital to Analogue, Digital signal processing, Digital logic, Data presentation system

Unit 3: Actuation **(10 Hrs.)**

Unit 3.1:

Pneumatic and Hydraulic Actuator: Introduction, Direction control valve, Pressure control valve, cylinders.

Mechanical Actuator: Mechanical systems, types of motions, kinematic chain, cam, gears, belt and chain drive, bearings.

Electrical Actuator: Electrical systems, Mechanical switches, solid state switches, solenoids, DC motors, AC motors.

Unit 3.2:

Servo and proportional control valve, process control valve, rotary actuators, rachet and pawl, stepper motor and motor selection

Unit 4: Microprocessor systems **(12 Hrs.)**

Unit 4.1:

Microprocessor and Microcontroller: Control, Microprocessor systems, Microcontroller, Applications, programming.

Assembly Language: Languages, Instruction sets, Assembly language programs, subroutines, look up table, embedded systems.

Input and Output Systems: Interfacing, requirement, I/O addressing, peripheral interface adapters, serial communication interfacing.

PLC.

Unit 4.2:

C language, fault finding, communication systems.

Unit 5: System Models **(7 Hrs.)**

Unit 5.1:

Basic system models, system models, dynamic response of systems, system transfer function, frequency response, closed-loop controllers, Artificial intelligence

Unit 5.2:

Mathematical models, Linearity.

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

Text Books:

T1: "Mechatronics: Electronic Control System in Mechanical and Electrical Engineering", William Bolton, Pearson Education, 6th Edition, 2015

T2: "Mechatronics: Integrated Mechanical Electronic", K.P. Ramachandran, G.K. Vijayaraghavan, M.S.Balasundaram, Wiley Publication, 2019.

T3: "A Textbook of Mechatronics", R. K. Rajput, S Chand Publication, 2007

Reference Books:

R1. "Mechatronics : Principles, Concepts and Applications ", Nitaigour Mahalik, Mc-Graw Hill Education, 1st Edition, 2017.

R2. "Mechatronics", Tilak Thakur, Oxford University Press, 1st Edition, 2017.

Open Sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering
- http://www.myopencourses.com/discipline/mechanical-engineering

(Sessional/Practical)

Experiment(s) Detail:

Experiment 1.	To perform the 8 - bit addition using 8085 Microprocessor.
Experiment 2.	To perform the 8 - bit Subtraction using 8085 Microprocessor.
Experiment 3.	To perform the 8 - bit Multiplication using 8085 Microprocessor.
Experiment 4.	To perform the 8 - bit Division using 8085 Microprocessor.
Experiment 5.	To run a stepper motor at different speeds and different directions using 8051 assembly language
Experiment 6.	To measure the speed of DC motor using optical sensor
Experiment 7.	To study the characteristics between the strains applied to the cantilever beam strain sensor and the bridge voltage.
Experiment 8.	To construct a hydraulic circuit to control the continuous actuation of a double acting cylinder using 5/2double pilot valve
Experiment 9.	To construct an electro - pneumatic circuit to control the double acting cylinder using 5/2 single pilot valve
Experiment 10.	To study of image processing technique

Open Sources/Virtual lab:

https://vlab.amrita.edu/?sub=62&brch=271

Virtual Labs - Mechanical Engineering (vlab.co.in)

Mechanical Engineering Department

Subject Name: Design of HVAC Systems (L:T:P-3:0:3)

Regulation Year: 2020-24/2021-25

Course Code: MHE 23431 **Credit:** 5

Course Category: Program Elective **Contact hours:** 36

Recommended Pre-requisite: Thermodynamics, Heat Transfer, Fluid Mechanics

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Understand the data reading for inside design condition

CO2: Evaluate the size of air conditioning components

CO3: Apply working principle of VCR system to design different types of duct and other components.

CO4: Understand basics of piping systems

CO5: Analyze Selection of fan for various applications

THEORY PART (CONTENTS)

Unit 1: **(7Hrs.)**

Introduction

Location, Weather data, Orientation, Solar Radiation - U factors and shading coefficients of building envelopes, Heat Gain through envelopes – Infiltration and ventilation loads – outside and inside design conditions, Internal loads, equivalent temperature difference, daily range etc., Procedure for heating and cooling load estimation: Dehumidifed air quantity, ETH, ESHF, GTH, Interpretation of heat load estimations, Procedures for estimation of cooling load, hands on exercise

Unit 2: **(7 Hrs.)**

Selection of systems for different Applications

Residential, Commercial – Hotels, Mall, Hospitals, Industrial etc. Window, Ductless split ACs, Package and Ductable units, VRFs/VRV, large DX systems with AHUs, Fans, Cooling towers and other allied components.

Unit 3: **(8 Hrs.)**

Duct

Study of Architectural / structural layout of interiors, Location of AHUs, Duct design methodologies, Different types of duct design, Selection of air terminals, dampers, filters etc. Pressure drop estimation, Constant volume systems, variable air volume systems, VAV boxes, Single duct cooling and heating, VAV with parallel and series fan powered, induction VAVs, accessories involved, Hands on exercises, Types of Room Air Distribution Systems: Mixing Air, Displacement, Unidirectional and Under-Floor.

Unit 4: (7 Hrs.)

Water piping systems

Open and closed piping systems, piping routing, pipe sizing – flow, velocity, pressure drop, Accessories - expansion / make up water tank, Valves and fittings, Calculation of total pressure drop across the piping circuit, Chemical dosing, NPSH calculations, pressure testing parameters,

Refrigerant piping systems

Criteria for sizing suction, liquid, hot gas line, pressure drop, oil return, schematic layout of systems, and best practices, pressure testing parameters, Accessories.

Unit 5: (7 Hrs.)

Fan

Law, Types including ventilation, Selection of fan for various applications, Power, Efficiency, Motor sizing, Noise level, Static pressure, operation and performance issues, Chilled and cooling water

Types, Selection, Head Requirement, Motor sizing, Operation and Performance issues

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

SESSIONAL/PRACTICAL/LAB PART (CONTENTS)

HVAC DRAFTING SYLLABUS

List of experiments: *(Minimum 10 experiments)*

Requirements: *AutoCAD 2D Knowledge*

1. Introduction To HVAC Drafting, How A Drafting Project Executes, Legends And Abbreviations.
2. Types Of Layouts, · Architectural layout, Structural layout, Electrical layout Mechanical layout, HVAC layout, Firefighting layout
3. Type Of False Ceiling, Plain false ceiling, Tiles or grid false ceiling, Step false ceiling
4. Creating Layers
5. Creating Air Terminals (SAD, RAD, SCD, RCD)
6. Creating Duct Fittings, Reducer, trouser piece, Elbow, Mouth piece, Canvas cloth, Flexible ducts etc.
7. Conversion Of Civil Multicolor Drawing To Single Color
8. Single Line Drawing In Ducting, Placement of Indoor Unit, Placement of Air Terminals, Single line ducting, Accessories (VAV, VCD, FD ETC)
9. Double Line Drawing In Ducting, Placement of Indoor Unit, Placement of Air Terminals,

Double line ducting, Accessories placement

10. Insulation, Acoustic insulation, Thermal Insulation,
11. Single Line Piping,· Rooting of piping, Sizing (using chart), Valves fitting,
12. Double Line Piping, Conversion of single line piping to double line pipe, Pipe fitting, Elbow, Tee, Reducer, Labeling

Text Books:

T1: Stoecker W.F., Refrigeration and Air conditioning, McGraw-Hill Book Company, 1989

T2: Dossat R.J., Principles of refrigeration, John Wiley, S.I. Version, 2001

T3: Ysen - Yao Sun, Air handling system design, McGraw–Hill, Inc., NY – 1994

Reference Books:

R1. ASHRAE, Fundamentals, Refrigeration, Systems and Equipment, Applications

R2. Wilbert F.Stoecker, Industrial Refrigeration Hand Book, McGraw-Hill, 1998

R3. ISHRAE Handbook, Air conditioning, Refrigeration, Ventilation

Open Sources:

https://www.udemy.com/course/smtmephdb

Department of Mechanical Engineering

Subject Name: Welding Technology (L:T:P-3:0:3)

Regulation Year: 2020-24

Course Code: MHE 23422 **Credit: 5**

Course Category: Program Elective **Contact hours: 60 Hrs.**

Recommended Pre-requisite:

1. Engineering Metallurgy
2. Basic Manufacturing Processes

COURSE OUTCOMES: After going through this course the student will be able to

CO1	Understand the theoretical aspects of welding technology in depth.
CO2	Acquire knowledge about the basic metallurgy of the melted and heat-affected zone of a metal or alloy.
CO3	Acquire knowledge about different types basic welding processes.
CO4	Acquire knowledge about weld joint preparation and temperature control.
CO5	Acquire knowledge about to check the weldment quality using various inspection and testing methods.

Course Details:

Unit 1: Introduction to welding and joining processes (8 Hrs.)

Introduction to consolidation processes, Classification of welding processes, some common concerns, types of fusion welds and types of joints, Design considerations, Heat effects, Weld ability and join ability. Welding terms and definitions, welding positions, elements of and construction of welding symbols.

Unit 2: Welding Metallurgy (8 Hrs.)

Fundamentals of physical metallurgy; Solidification of weld metal: Principle of solidification of weld; Heat affected zone and weld metal; Metallurgical issue in weld joint.

Unit 3: Basic Welding Processes (8 Hrs.)

Theory of gas welding, resistance welding, arc welding (SMAW, GMAW, FCAW, GTAW, SAW), solid state welding (friction welding) and other welding processes.

Unit 4: Weld joint preparation and temperature control **(8 Hrs.)**

Checks prior to weld joint preparation, joint preparation checks, preheating and interpass heating, post weld heating, heating processes, post heat treatments, insulation of heated joints. Welding power sources (features); Consumable and Non-consumable electrode Arc welding process.

Unit 5: Weldment Inspection and Testing **(8 Hrs.)**

Codes governing welding inspection: Structural welding code; Chemical, Metallurgical, and Mechanical testing of weldments; Non-destructive Testing used for joint inspection.

Text Books:

T1. Lancaster J F, "Metallurgy of welding", Allen and Unwin Co.

T2. K Esterling, "Introduction to Physical Metallurgy".

T3. Parmer R. S., 'Welding Engineering and Technology', Khanna Publishers, 1997.

T4. Hull., 'Non-Destructive Testing', ELBS Edition, 1991.

Reference Books:

R1. "Welding Handbook", Volumes 1, 2 and 3, 9th edition, American Welding Society.

R2. Larry J and Jeffus L, "Welding Principles and Applications", 5th edition, Delmer Publications.

R3. ASME Section IX.

R4. Modern Arc Welding Technology by S.V. Nadkarni (Publisher: Oxford & IBH).

Open Sources:

https://nptel.ac.in

https://ocw.mit.edu/courses/mechanical-engineering/

https://www.classcentral.com/provider/swayam

https://www.coursera.org/in

https://www.mooc.org/

Experiment Details:

Experiment 1	Introduction to lab, safety aspects and welding power sources regarding arc and resistant welding.
Experiment 2	Prepare a butt joint with mild steel plate using SMAW technique.
Experiment 3	Prepare a butt joint with mild steel sheet using GMAW technique.
Experiment 4	Prepare a butt joint with mild steel sheet using GTAW technique.
Experiment 5	Prepare a butt joint with mild steel plate using SAW technique.
Experiment 6	Prepare a lap joint with mild steel sheet using GMAW technique.
Experiment 7	Prepare a lap joint with mild steel sheet using RSW technique.
Experiment 8	Tensile test and bending test of butt welded joint.
Experiment 9	Non-destructive testing of butt welded joint.
Experiment 10	Microstructural study of base metal, heat affected zone and weld metal.

Open Sources/Virtual lab:

https://nptel.ac.in

https://www.youtube.com

Subject Name: Robotics and Robot Applications (L:T:P-3:0:3)

Regulation Year: 2020 – 24 / 2021-25

Course Code: MHE 23435 **Credit: 05**

Course Category: Program Elective **Contact hours: 60 hrs**

Recommended Pre-requisite:

1. Engineering Mechanics
2. Engineering Mathematics
3. Mechanics of Machines
4. Basics of Electrical and Electronics

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Understand the fundamentals of robotics and automation

CO2: Analyze robot arm kinematics of various manipulator configurations.

CO3: Design appropriate robot grippers for various applications.

CO4: Design the robot drives, sensors, actuators for the given task

CO5: Apply program code for simple robot in manufacturing application

Course Details:

Unit1: Fundamental of Robotics **(08 Hrs.)**

Introduction, Automation and Robotics, A brief History of Robotics, Laws of Robots, Definition of Robot Anatomy & Classification of Robots, Specification of Robots, Work Volume, Robot Precession, The Robotics Market, Social Issues and Future Prospects.

Unit2: Robot Arm Kinematics **(10 Hrs.)**

Introduction to Robot Arm Kinematics, Position analysis and finite rotation and translation, Direct and Inverse Kinematics, Composite Homogeneous Transformation Matrix, Denavit-Hartenberg (DH) Parameters.

Unit3: Robot Grippers **(06 Hrs.)**

Types of End Effectors, Robot Grippers, Magnetic Grippers, Vacuum Grippers, Adhesive Grippers, Multifingered Gripper, Other Special Grippers – RCC, Design aspect for grippers - Force Analysis for various basic gripper systems.

Unit4: Robot Drives, Sensors, Actuators **(06 Hrs.)**

Robot Drive Systems – Hydraulic, Pneumatic & Electric- characteristics and comparison, Characteristics of sensing devices, Sensors for Robots – Contact & Noncontact type sensors, Force & Torque Sensors, Robotic Vision Systems – image acquisition, digitization, image processing and analysis.

Unit5: Robot Programming–Language & Applications in Manufacturing (06 Hrs.)

Methods of Robot Programming, Robot Programming - Language overview, command for elementary operations.
Robot Application Area – Material Handling and Machine Loading/Unloading, Processing Operation, Assembly & Inspection, Future Manufacturing Application of Robots.

Text Books:

1. Mikell P. Groover, Mitchell Weiss, Industrial Robotics Technology – Programming and Applications, 2nd edition, McGraw Hill, 2013.
2. S. R. Deb, Sankha Deb, Robotics Technology And Flexible Automation, 2nd edition, McGraw Hill Education, 2017.
3. S.K.Saha, Introduction to Robotics, McGraw-Hill, 2nd Edition, 2014

Reference Books:

1. Niku, Saeed. B, Introduction to Robotics: Analysis, Systems, Applications, Prentice Hall of India Pvt. Ltd , New Delhi, 2011.
2. R.K. Mittal and I.J. Nagrath, Robotics and Control, Tata McGraw Hill, 1st Edition, 2003.

Open Sources:

1. NPTEL Video course on Robotics: http://www.nptelvideos.in/search?q=robotics
2. "Introduction to Robotics" course available at MIT Open courseware: https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/index.htm
3. Webots: A open source mobile robot simulation software package https://cyberbotics.com/
4. RoboAnalyzer-A 3D model based software for learning the Robotics concepts: http://www.roboanalyzer.com/
5. Lego Mindstorm EV3- Robot building and Programming Kit: https://www.lego.com/en-in/product/lego-mindstorms-ev3-31313

(Sessional/Practical)

Experiment Details:

Experiment 1	Demonstration of Robot with different Degree of Freedom (DOF)
Experiment 2	Study of different configurations of robots for degrees of freedom, number of links, and other parameters using simulation software like Roboanalyzer
Experiment 3	Understanding coordinate frames and transformations

Experiment 4	Determination of end effector transformation matrix of an industrial robot using a suitable software like Roboanalyzer
Experiment 5	Generalized MATLAB code for determination of end effector transformation matrix of an industrial robot.
Experiment 6	Selection of appropriate Sensors for a given robotic application
Experiment 7	Selection of appropriate Actuators for a given robotic application
Experiment 8	Programming exercise of Robots for pick and place activity
Experiment 9	Simulation of a robotic motion using software like Roboguide
Experiment 10	Programming exercise of Robots for welding activity
Experiment 11	Programming exercise of Robots for welding activity using simulator

Open Sources/Virtual lab:

http://vlabs.iitkgp.ernet.in/mr/

https://vlab.amrita.edu/?sub=62&brch=271

Department of Mechanical Engineering

Subject Name: Introduction to Robotics (L:T:P-3:0:0)

Regulation Year: 2020 – 24 / 2021-25

Course Code: MHE 21511 **Credit: 03**

Course Category: Open Elective **Contact hours: 36 hrs**

Recommended Pre-requisite:

1. Engineering Mechanics
2. Engineering Mathematics
3. Basics of Electrical and Electronics

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Specify various types of Robots for industrial applications

CO2: Design appropriate end effectors for various applications.

CO3: Analyze kinematics of various manipulator configurations.

CO4: Design the robot drives, sensors, actuators for the given task

CO5: Apply program code for simple robot in manufacturing application

Course Details:

Unit1: Introduction to Industrial robot **(08 Hrs.)**

History of Robotics –Basics components of Robotics system – DOF and types of joints – Work space – Robot precession - Types of robotics configurations – Types of robotics drives – Basic motion of robot manipulator – Harmonics drives – Economics aspects of robotics system in industrial automations.

Unit2: Effectors and Grippers **(06 Hrs.)**

Types of end effector - Mechanical gripper – types of mechanical grippers – magnetic gripper – Vacuum gripper – Adhesive gripper – other special grippers – RCC –design of mechanical gripper.

Unit3: Robot kinematics **(10 Hrs.)**

Position analysis and finite rotation and translation – Homogeneous matrices – forward and inverse kinematics – DH representation.

Unit4: Sensor and Machine Vision system in robotics **(06 Hrs.)**

Range sensing, Triangulation, structured light approach, Light-of-flight range finder – Proximity sensing: Inductive, Hall-effect, capacitive and ultrasonic sensor –Touch sensing – Force and Torque sensing.

Introduction to Machine vision – Sensing and Digitizing – Image processing and analysis

Unit5: Applications & Robot programming **(06 Hrs.)**

Material handling, Machine loading and unloading, Robot assembly, Inspection, Welding, Obstacle avoidance, future application.

Classification of robotics - simple robot in palletizing and de- palletizing – simple robot program in robot arc welding.

Text Books:

1. Mikell P. Groover, Mitchell Weiss, Industrial Robotics Technology – Programming and Applications, 2nd edition, McGraw Hill, 2013.
2. S. R. Deb, Sankha Deb, Robotics Technology And Flexible Automation, 2nd edition, McGraw Hill Education, 2017.
3. S.K.Saha, Introduction to Robotics, McGraw-Hill, 2nd Edition, 2014

Reference Books:

1. Niku, Saeed. B, Introduction to Robotics: Analysis, Systems, Applications, Prentice Hall of India Pvt. Ltd , New Delhi, 2011.
2. R.K. Mittal and I.J. Nagrath, Robotics and Control, Tata McGraw Hill, 1st Edition, 2003.

Open Sources:

1. NPTEL Video course on Robotics: http://www.nptelvideos.in/search?q=robotics
2. "Introduction to Robotics" course available at MIT Open courseware: https://ocw.mit.edu/courses/mechanical-engineering/2-12-introduction-to-robotics-fall-2005/index.htm
3. Webots: A open source mobile robot simulation software package https://cyberbotics.com/
4. RoboAnalyzer-A 3D model based software for learning the Robotics concepts: http://www.roboanalyzer.com/
5. Lego Mindstorm EV3- Robot building and Programming Kit: https://www.lego.com/en-in/product/lego-mindstorms-ev3-31313

Mechanical Engineering Department

Subject Name: Introduction to Microfluidics (L:T:P-3:0:0)

Regulation Year: 2020-24/2021-25

Course Code: MHE 21513 **Credit:** 3

Course Category: Open Elective **Contact hours:** 42

Recommended Pre-requisite: Fluid Mechanics

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Demonstrate the fundamental understanding of microfluidics.

CO2: Interpret capillary flows and electro kinetics.

CO3: Describe the microfabrication techniques

CO4: Describe the microfluidics components.

THEORY PART (CONTENTS)

Unit 1: **(10 Hrs)**

Micro-Scale Fluid Mechanics

Introduction:

Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws.

Fundamentals:

Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations. Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects. Exact solutions, Couette flow, Poiseuille flow, Stokes drag on a sphere, Time-dependent flows, Two-phase flows, Thermal transfer in microchannels. Hydraulic resistance and Circuit analysis. Straight channel of different cross-sections, Channels in series and parallel.

Unit 2: **(10 Hrs)**

Capillary Flows & Electrokinetics

Capillary Flows:

Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length, and capillary rise, Interfacial boundary conditions, Marangoni effect.

Electrokinetics:

Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electroosmotic flow, Ideal EOF with backpressure, Cascade electroosmotic micropump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Di-electrophoresis, Induced polarization, and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric.

Unit 3: **(10 Hrs)**

Microfabrication Techniques

Materials, Cleanroom, Silicon crystallography, Miller indices. Oxidation, photolithography- mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer microfabrication, PMMA/COC/PDMS substrates, micro-molding. Hot embossing, fluidic interconnections.

Unit 4: **(6 Hrs)**

Microfluidics Components-I

Micropumps, Check-valve pumps, Valve-less pumps, Peristaltic pumps, Rotary pumps, Centrifugal pumps, Ultrasonic pumps, EHD pumps, MHD pumps. Microvalves, Pneumatic valves, Thermopneumatic valves, Thermomechanical valves, Piezoelectric valves, Electrostatic valves, Electromagnetic valves, Capillary force valves. Microflow sensors, Differential pressure flow sensors. Drag force flow sensors, Lift force flow sensors, Coriolis flow sensors.

Unit 5: **(6 Hrs)**

Microfluidics Components-II

Thermal flow sensors. Micromixers, Physics of mixing, Pe-Re diagram of micromixers, Parallel lamination, Sequential lamination, Taylor-Aris dispersion. Droplet generators, Kinetics of a droplet, Dynamics of a droplet, In-channel dispensers, T-junction and Cross-junction, Droplet formation, breakup, and transport. Microparticle separator, principles of separation and sorting of microparticles, design, and applications. Microreactors, Design considerations, Liquid-phase reactors, PCR, Design consideration for PCR reactors.

Note:

At least 5 (Five) Assignments to be given to the students out of which the best three can be taken for final assessment.

Text Books:

T1: Nguyen, N. T., Werely, S. T., *Fundamentals and applications of Microfluidics*, Artech house Inc., 2002.

T2: Tabeling, P., *Introduction to microfluidics*, Oxford University Press Inc., 2005.

T3: Bruus, H., *Theoretical Microfluidics*, Oxford University Press Inc., 2008.

Reference Books:

R1. Kirby, B.J., *Micro- and Nanoscale Fluid Mechanics*: *Transport in Microfluidic Devices*, Cambridge University Press, 2010.

R2. Colin, S., *Microfluidics*, John Wiley & Sons, 2009.

R3. Madou, M. J., *Fundamentals of Microfabrication*, CRC Press, 2002.

Open Sources:

- https://nptel.ac.in/courses/112/105/112105187/
- https://nptel.ac.in/courses/112/106/112106169/
- https://onlinecourses.nptel.ac.in/noc19_bt27/preview
- https://www.classcentral.com/course/swayam-biomicrofluidics-13923

Mechanical Engineering Department

Subject Name: Renewable Energy Resources (L:T:P-3:0:0)

Regulation Year: 2020-24/2021-25

Course Code: MHE 21515 **Credit:** 3

Course Category: Open Elective **Contact hours:** 40

Recommended Pre-requisite: Thermodynamics, Heat Transfer

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Acquire knowledge on current energy scenario and potential of non-conventional energy and introduction on how to use and store solar energy.

CO2: Explain the hot water system, solar pond and non-convective solar pond and familiarize with the concept of the concept of solar cell and their application.

CO3: Have knowledge of conversions of geothermal energy and understanding of wind energy system and its application.

CO4: Understand technologies involved in converting other sources of non-conventional energy like biomass and biogas.

CO5: Understand the basic concepts on Ocean temperature differences, OTEC systems and its recent development and tidal energy

THEORY PART (CONTENTS)

Unit 1: **(08 Hrs.)**

Introduction: Causes of Energy Scarcity, Solution to Energy Scarcity, Factors Affecting Energy Resource Development, Energy Resources and Classification, Renewable Energy – Worldwide Renewable Energy Availability, Renewable Energy in India.

Energy from Sun: Sun- earth Geometric Relationship, Layer of the Sun, Earth – Sun Angles and their Relationships, Solar Energy Reaching the Earth's Surface, Solar Thermal Energy Applications

Unit 2: **(08 Hrs.)**

Solar Thermal Energy Collectors: Hot water system, practical consideration, solar ponds, Non-convective solar pond, extraction of thermal energy and application of solar ponds.

Solar Cells: Components of Solar Cell System, Elements of Silicon Solar Cell, Solar Cell materials, Practical Solar Cells, I – V Characteristics of Solar Cells, Efficiency of Solar Cells, Photovoltaic Panels, Applications of Solar Cell Systems

Unit 3: **(08 Hrs)**

Wind Energy: Wind energy: The nature of wind. Wind energy resources and modelling.

Geothermal Energy: Geothermal Systems, Classifications, Geothermal Resource Utilization, Resource Exploration, Geothermal Based Electric Power Generation, Associated Problems, environmental Effects.

Unit 4: **(08 Hrs)**

Biomass Energy: Biomass Production, Energy Plantation, Biomass Gasification, Theory of Gasification, Gasifier and Their Classifications, Chemistry of Reaction Process in Gasification, Updraft, Downdraft and Cross-draft Gasifiers, Fluidized Bed Gasification, Use of Biomass Gasifier, Gasifier Biomass Feed Characteristics, Applications of Biomass Gasifier, Cooling and Cleaning of Gasifiers.

Biogas Energy: Introduction, Biogas and its Composition, Anaerobic Digestion, Biogas Production, Benefits of Biogas, Factors Affecting the Selection of a Particular Model of a Biogas Plant, Biogas Plant Feeds and their Characteristics.

Unit 5: **(08 Hrs)**

Tidal energy: Fundamentals. Availability Tidal-energy conversion systems.

Ocean Thermal Energy: Introduction, Principles of Ocean Thermal Energy Conversion (OTEC), Ocean Thermal Energy Conversion plants, Basic Rankine Cycle and its Working, Closed Cycle, Open Cycle and Hybrid Cycle, Carnot Cycle, Application of OTEC in Addition to Produce Electricity, Advantages, Disadvantages and Benefits of OTEC.

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

Text Books:

T1: S.P.Sukhatme, Solar Energy Principle of Thermal Collection and Storage', Tata McGraw Hill, 1990.

T2: G.L. Johnson, Wind energy systems, Prentice Hall Inc. New Jersey.

T3: J.M.Kriender, Principles of Solar Engineering', McGraw Hill, 1987.

Reference Books:

R1: V.S. Mangal, Solar Engineering', Tata McGraw Hill, 1992.

R2: N.K.Bansal, Renewable Energy Source and Conversion Technology', Tata McGraw Hill, 1989.

R3: P.J. Lunde., Solar Thermal Engineering', John Willey & Sons, New York, 1988.

R4: J.A. Duffie, and W.A. Beckman, _Solar Engineering of Thermal Processes', Wiley & Sons, 1990

Open Sources:

- **NPTEL:** https://nptel.ac.in/courses/103/103/103103206/
- **COURSERA:**https://www.coursera.org/lecture/sustainability/renewable-energy-TVHGS
- **MIT OPEN COURSEWARE:** https://energy.mit.edu/area/renewable-energy/

Mechanical Engineering Department

Subject Name: Solar Energy Technology (L:T:P-3:0:0)

Regulation Year: 2020-24/2021-25

Course Code: MHE 21517 **Credit:** 3

Course Category: Open Elective **Contact hours:** 40

Recommended Pre-requisite: Thermodynamics, Heat Transfer

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: describe the working principles of solar cells and solar collectors.

CO2: evaluate different solar energy technologies through knowledge of the physical function of the devices.

CO3: estimate the size of solar cell systems and solar collectors for specified power requirements.

CO4: compare different solar energy systems.

CO5: communicate technological, environmental and socio-economic issues around solar energy

THEORY PART (CONTENTS)

Unit 1: **(8 Hrs.)**

Solar radiation

Extra-terrestrial and terrestrial radiation; Earth-Sun relation: Solar angles, Sun path diagram; Shadow determination, Solar spectrum, Effect of earth atmosphere on solar radiation, Solar radiation measurement devices. Measurement and estimation of solar radiation on horizontal and tilted surfaces, Solar radiation data analysis.

Unit 2: **(8 Hrs.)**

Solar cells and modules

The function of solar cells from semiconductor physics. Different solar cell technologies and fabrication methods. Concepts for increasing efficiency based on loss analysis. Wavelength sensitivity. Series connection of solar cells to modules. Module function and characteristics. Shading of cells and modules.

Unit 3: **(8 Hrs.)**

Solar cell systems

System components and their functions. Calculating output and dimensioning of solar cell systems. Concentrated sunlight and solar power (CSP). Properties of optical concentration systems. Solar cells in concentrated sunlight. Overview of the different components in a CSP system and their functions. Examples of CSP-systems globally. Analysis and computer simulation of a solar cell system.

Unit 4: **(10 Hrs.)**

Solar thermal conversion

Introduction to different solar thermal energy systems: Solar flat plate collector, concentrating collector, Solar cooker, Solar pond, Solar passive heating and cooling system, Solar cooling and refrigeration; Solar thermal power generation.

Unit 5: **(8 Hrs.)**

Hybrid systems

Combinations of solar thermal and solar cell systems. Overview of different applications. District heating with solar thermal components. Storage of solar generated heat

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

Text Books:

T1: Duffie, John A., and William A. Beckman. *Solar engineering of thermal processes*. John Wiley & Sons, 2013.

T2: Solanki, Chetan Singh. *Solar photovoltaics: fundamentals, technologies and applications*. Phi learning pvt. Ltd., 2015.

T3: Goswami, D. Yogi, Frank Kreith, and Jan F. Kreider. *Principles of solar engineering*. CRC Press, 2000.

Reference Books:

R1. Garg, H. P. *Solar energy: fundamentals and applications*. Tata McGraw-Hill Education, 2000.

R2. Sukhatme, Suhas P., and J. K. Nayak. *Solar energy*. McGraw-Hill Education, 2017.

R3. Green, Martin A. "Solar cells: operating principles, technology, and system applications." *Englewood Cliffs* (1982).

Open Sources:

- https://onlinecourses.nptel.ac.in/noc20_ph14/preview
- https://nptel.ac.in/courses/112/105/112105051/
- https://www.coursera.org/learn/solar-energy-basics

Department of Mechanical Engineering

Subject Name: Fundamentals of Mechatronics (L:T:P-3:0:0)

Regulation Year: 2020 – 24

Course Code: MHE 21521 **Credit: 03**

Course Category: Open Elective **Contact hours: 40 hrs**

Recommended Pre-requisite:

1. Engineering Mechanics
2. Basic Electronics Engineering
3. Basic Electrical Engineering
4. Engineering Mathematics
5. Theory of Machines

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Explain basic concepts of Mechatronics.

CO2: Identify sensors used in Mechatronics and will be able to condition the signals.

CO3: Select actuators used in different applications.

CO4: Analyze microprocessor systems

CO5: Design the system models mathematically.

Course Details:

Unit 1: Basics of Mechatronics **(3 Hrs.)**

Introduction, Design Process, Systems, Measurement systems, Control systems, Programmable logic controller

Unit 2: Sensors, Tranducers and Signal Conditioning **(8 Hrs.)**

Sensors and Transducers: Performance Terminology, Dispalcement, position and proximity, Velocity and motion, force, fluid pressure, liquid flow, temperature, light sensors, selection of sensors, inputing data by switches.

Signal Conditioning: OPAM, protection, filtering, wheatstone bridge, power transfer.

Unit 3: Actuators **(10 Hrs.)**

Pneumatic and Hydraulic Actuator: Introduction, Direction control valve, Pressure control valve.

Mechanical Actuator: Mechanical systems, types of motions, kinematic chain, cam, gears, belt and chain drive, bearings.

Electrical Actuator: Electrical systems, Mechanical switches, solid state switches, solenoids, DC motors, AC motors.

Unit 4: Microprocessor and Microcontrollers systems **(12 Hrs.)**

Microprocessor and Microcontroller: Control, Microprocessor systems, Microcontroller, Applications, programming.

Input and Output Systems: Interfacing, requirement, I/O addressing, peripheral interface adapters, serial communication interfacing. PLC.

Unit 5: System Models **(7 Hrs.)**

Basic system models, system models, dynamic response of systems, system transfer function, frequency response, closed-loop controllers.

Note:

At least 5 (Five) Assignments (one assignment from each unit) to be given to the students out of which the best three can be taken for final assessment.

Text Books:

T1: "Mechatronics: Electronic Control System in Mechanical and Electrical Engineering", William Bolton, Pearson Education, 6th Edition, 2015

T2: "Mechatronics: Integrated Mechanical Electronic", K.P. Ramachandran, G.K. Vijayaraghavan, M.S.Balasundaram, Wiley Publication, 2019.

T3: "A Textbook of Mechatronics", R. K. Rajput, S Chand Publication, 2007

Reference Books:

R1. "Mechatronics : Principles, Concepts and Applications ", Nitaigour Mahalik, Mc-Graw Hill Education, 1st Edition, 2017.

R2. "Mechatronics", Tilak Thakur, Oxford University Press, 1st Edition, 2017.

Open Sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering
- http://www.myopencourses.com/discipline/mechanical-engineering

Subject Name: Engineering Biomaterials (L:T:P-3:0:0)

Regulation Year: 2020-24/2021-25

Course Code: MHE 21523 **Credit: 3**

Course Category: Engineering Science **Contact hours: 30**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: know the need for biomaterials

CO2: know the use of Meatallic implant materials

CO3: know the use of Polymeric implant materials

CO4: know Ceramic implant materials

CO5: know Biocompatibility & Toxicological screening of biomaterials

Course Details:

Unit1: Introduction to biomaterials (6 Hrs)

Introduction: Introduction: Definition of biomaterials, requirements & classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties of materials, physical properties of materials, mechanical properties.

Unit 2: (7 Hrs)

Metallic implant materials: Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants: Percutaneous and skin implants, Vascular implants, Heart valve implants-Tailor made composite in medium.

Unit 3: (7 Hrs)

Polymeric implant materials: Polymeric implant materials: Polyolefin's, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetyls. (Classification according to thermo sets, thermoplastics and elastomers).Viscoelastic behavior: creep-recovery, stress-relaxation, strain rate sensitivity. Importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives (processing aids), aging and environmental stress cracking. Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymeric membranes and their biological applications.

Unit4: **(5 Hrs)**

Ceramic implant materials: Ceramic implant materials: Definition of bio ceramics. Common types of bio ceramics: Aluminum oxides, Glass ceramics, Carbons. Bio resorbable and bioactive ceramics. Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction). Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement (short and long fibers, fibers pull out). Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions.

Unit5: **(5 Hrs)**

Biocompatibility & Toxicological screening of biomaterials: Biocompatibility & Toxicological screening of biomaterials: Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situimplantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.

Text Books:

T1:-Biomaterials Science: An Introduction to Materials in Medicine, By Buddy D. Ratner, et. al. Academic Press, San Diego, 1996.

T2**: -** Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.

T3: - J B Park, Biomaterials – Science and Engineering, Plenum Press, 1984.

Mechanical Engineering Department

Subject Name: Introduction to Computational Fluid Dynamics (L:T:P-3:0:0)

Regulation Year: 2020-24

Course Code: MHE 21525 **Credit:** 3

Course Category: Open Elective **Contact hours:** 42

Recommended Pre-requisite: Fluid Mechanics, Numerical Methods

COURSE OUTCOMES: After going through this course the student will be able to (***Collective for theory & lab parts***)

CO1: Demonstrate the basic understanding of Fluid Mechanics & Numerical Methods

CO2: Illustrate the understanding of FED & FEM.

CO3: Describe FVM and discretization of Navier-Stokes Equations

CO4: Demonstrate the understanding of Turbulence Modeling.

THEORY PART (CONTENTS)

Unit 1: **(7 Hrs)**

Overview of Fluid Mechanics

Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description.

Classification and Overview of Numerical Methods

Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions. Overview of Numerical Methods.

Unit 2: **(10 Hrs)**

Finite Difference Methods

Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of FD method. Accuracy of FD method.

Unit 3: **(10 Hrs)**

Finite Element Methods

Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements. Applications.

Unit 4: **(10 Hrs)**

Finite Volume Technique

Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations.

Numerical Grid Generation

Numerical grid generation; basic ideas; transformation and mapping.

Naiver-Stokes Equations

Explicit and implicit methods; SIMPLE type methods; fractional step methods. Comparison for convection-diffusion problem.

Unit 5: **(5 Hrs)**

Turbulence modeling

Reynolds averaged Navier-Stokes equations, RANS modeling. DNS and LES.

Note:

At least 5 (Five) Assignments to be given to the students out of which the best three can be taken for final assessment.

Text Books:

T1: Ferziger, J. H. and Peric, M. (2003). *Computational Methods for Fluid Dynamics*. Third Edition, SpringerVerlag, Berlin.

T2: Versteeg, H. K. and Malalasekara, W. (2008). *Introduction to Computational Fluid Dynamics: The Finite Volume Method*. Second Edition (Indian Reprint) Pearson Education.

T3: Anderson, D.A., Tannehill, J.C. and Pletcher, R.H. (1997). *Computational Fluid Mechanics and Heat Transfer*. Taylor & Francis.

Reference Books:

R1. S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, McGraw-Hill.

R2. T. J. Chung, *Computational Fluid Dynamics*, Cambridge University Press.

R3. John D. Anderson Jr, *Computational Fluid Dynamics*, McGraw Hill Book Company.

Open Sources:

- https://nptel.ac.in/courses/101/106/101106045/
- https://nptel.ac.in/courses/112/105/112105045/
- https://nptel.ac.in/courses/112/107/112107079/

Department of Mechanical Engineering

Subject Name: Finite Element Methods (L:T:P-3:0:0)

Regulation Year: 2020 – 24

Course Code: MHE 21527 **Credit: 03**

Course Category: Open Elective **Contact hours: 40 hrs**

Recommended Pre-requisite:

1. Engineering Mechanics
2. Engineering Mathematics
3. Heat and Mass Transfer
4. Mechanics of Solids
5. Fluid Mechanics

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Explain basic principles involved in the FEM.

CO2: Analyze Truss structures and Flexure Elements.

CO3: Select elements for FEM analysis and will be able to use FEM in Heat Transfer analysis

CO4: Analyze fluid flow using FEM

CO5: Use FEM in solid Mechanics analysis.

Course Details:

Unit 1: Basics of Finite Element Method **(7 Hrs.)**

Introduction, General Procedure of Finite Element Analysis, Stifness Matrices, Spring and Bar elements, Strain Energy, Castigiliano's First Theorem, Minimum Potential Energy.

Unit 2: Truss Structures and Flexure Elements **(11 Hrs.)**

Truss Structures (Direct Stiffness Method): Nodal Equilibrium Equation, Element transformation, Global Stifness Matrix, Boundary Conditions, Constraint Forces, Element strain and stress

Flexure Elements: Elementary Beam Theory, Flexure Element, Flexure Element Stiffness Matrix, Element Load Vector, Work equivalence for Distributed Load, Flexure Element with Axial Load

Unit 3: Element Formulation and Heat Transfer analysis using FEM **(10 Hrs.)**

Element Formulation: Introduction, Compatibility and Completeness Requirement, One Dimensional Elements, Geometric Isotropy, Triangular Elements, Rectangular Elements.

Heat Transfer: Introduction, One dimensional Conduction: Quadratic Element, One Dimensional Conduction with Convection.

Unit 4: Fluid Flow analysis using FEM (6 Hrs.)

Introduction, Governing Equations for Incompressible Flow, The steam function in Two-Dimensional Flow, The Velocity Potential Function in 2 D Flow.

Unit 5: Solid Mechanics analysis using FEM (6 Hrs.)

Introduction, Plane stress, Plane strain: Rectangular element, Isoparametric formulation of the Plane Quadriletral element, Axisymmetric Stress Analysis.

Text Books:

T1:- "Fundamentls of Finite Element Analysis", David Hutton, McGraw-Hill Publication , 1st Edition, 2004

T2: "Finite Element Analysis", S. S. Bhavikatti, New Age Publication, 3rd Edition, 2015.

T3: "A Text Book of Finite Element Analysis", P.Seshu, PHI Publication, 1st Edition, 2003

Reference Books:

R1. "Introduction to Finite Element in Engineering", T.R .Chandrupatta and A.D.Belegundu, Pearson Education India, 4th Edition, 2015.

R2. "An Introduction to the Finite Element Method", J.N. Reddy, Tata McGraw-Hill, 4th Edition, 2020.

R3. "The finite element method", T. J. R. Hughes, PRENTICE-HALL, INC, Englewood Cliffs, New Jersey.

R4. " Practical Finite Element Analysis", N.S. Gokhale, Finite to Infinite Publication, 2008 Edition

Open Sources:

- http://nptel.ac.in
- http:// ocw.mit.edu/courses/mechanical-engineering
- http://www.myopencourses.com/discipline/mechanical-engineering

Mechanical Engineering Department

Subject Name: Optimization Engineering (L:T:P-3:0:0)

Regulation Year: 2020-2024/2021-2025

Course Code: MHE 21529 **Credit: 03**

Course Category: Open Elective **Contact hours: 40**

COURSE OUTCOMES: After going through this course the student will be able to

CO1: Formulate and solve linear programming problems

CO2: Solve the problems on networks models such as Transportation, Assignment, Shortest path, minimal spanning tree, and Maximal flow.

CO3: Solve the problems of Project Management using CPM and PERT

CO4: Solve Non-linear Programming problems of some kinds.

CO5: Implement the advanced optimization technique.

Course Details:

Unit1: Linear Programming: **(08Hrs)**

Introduction to linear programming formulation of different models. Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex and revised simplex methods, Exceptional cases in LP, Duality theory, Dual Simple method, Sensitivity analysis.

Unit2: Network Analysis: **(08 Hrs)**

Transportation problem (with transshipment), Assignment problem, Traveling-salesman problem, Shortest route problem, Minimal spanning tree, Maximum flow problem

Unit 3: CPM and PERT: **(08 Hrs)**

Drawing of networks, Removal of redundancy, Network computations, Free slack, Total slack, Crashing. Resource allocation.

Unit 4: Non-Linear Programming **(08 Hrs)**

Introduction to non-linear programming formulation of different models, Characteristics, Concepts of convexity, maxima and minima of functions of n-variables using Lagrange multipliers and Kuhn-Tuker conditions, One dimensional search methods, Fibonacci, golden section method and gradient methods for unconstrained problems, One dimensional search methods, Fibonacci, golden section method and gradient methods for unconstrained problems.

Unit 5: Advanced Optimization Techniques (08 Hrs)

Genetic Algorithm, working principles, GAs for constrained optimization, Other GA operators, Advanced GAs, Differences between GAs and traditional methods, Particle swarm optimization method, working principles.

Text Books:

T1. Taha, H.A., Operations Research: An Introduction, Prentice Hall of India (2007) 8th ed.

T2. Kasana, H.S., Introductory Operation Research: Theory and Applications, Springer Verlag (2005).

Reference Books:

R1. Rardin, Ronald L., Optimization in Operations research, Pearson Education (2005).

R2. Ravindran A, Phllips D.T. and Solberg J.J. Operation Research: Principles and Practice, John Wiley (2007).

Open Sources:

https://nptel.ac.in/