College of Engineering, Pune

(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Mechanical Engineering

Curriculum Structure & Detailed Syllabus (UG Program)

Final Year B. Tech.

(Effective from: A.Y. 2022-23)

Program Education Objectives (PEOs):

I. Cater to the needs of Indian as well as multinational industries

II. Be competent with strong technological background to analyze data, formulate and undertake industrial problems and obtain viable solutions

III. Make successful career in industry / research / higher Studies

IV. Be life-long learning and should be able to work on multi-disciplinary projects

V. Be Competent for effective communication, in management and in professional skills and ethics

Program Outcomes (POs):

On successful completion Graduates will demonstrate:

1. Engineering knowledge
2. Problem analysis
3. Design/development of solutions
4. Conduct investigations of complex problems
5. Modern tool usage
6. The engineer and society
7. Environment and sustainability
8. Ethics
9. Individual and team work
10. Communication
11. Project management and finance
12. Life-long learning

Correlation between the PEOs and the POs

PO→ PEO↓	1	2	3	4	5	6	7	8	9	10	11	12	PSO1	PSO2	PSO3
I	✓		✓		✓	✓	✓				✓		✓		✓
II	✓	✓	✓		✓								✓		
III				✓		✓		✓	✓			✓		✓	✓
IV		✓	✓		✓					✓	✓	✓	✓	✓	✓
V						✓		✓	✓	✓	✓				✓

Programme Specific Objectives (PSOs):

I. Apply concepts of Design, Production and Thermal-fluid sciences to solve engineering problems utilizing advanced technology.

II. Use mechanical engineering software for the design and analysis of mechanical engineering systems/processes.

III. Extend and implement new thoughts on product design and development with the aids of modern CFD and CAD/CAM/CAE tools, while ensuring best manufacturing practices.

List of Abbreviations

Sr. No.	Abbreviation	Stands for:
1	BSC	Basic Science Course
2	DEC	Department Elective Course
3	HSMC	Humanities, Social Sciences including Management courses
4	IFC	Interdisciplinary Foundation Course
5	IOC	Interdisciplinary Open Course
6	LC	Laboratory Course
7	MLC	Mandatory Learning Course
8	PCC	Program Core Course
9	SBC	Skill Based Course

CURRICULUM STRUCTURE OF Final Year B.TECH (Mechanical)

Effective from A. Y. 2022-2023

VII-Semester: [M-Group]: Scheme A

Sr. No	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	MLC		Intellectual Property Rights	1	0	0	0
2	LLC		Liberal Learning Course	1	0	0	1
3	IOC		Interdisciplinary Open Course-II	2	0	0	2
4	DEC		Department Elective-II [Option among minimum 3 courses]	3	0	0	3
5	PCC	ME-22001	Automatic Control System	3	0	0	3
6	PCC	ME-22002	Refrigeration and Air Conditioning	3	0	0	3
7	PCC	ME-22003	CAD and Digital Manufacturing	2	0	0	2
8	LC	ME-22004	Refrigeration and Air Conditioning Lab	0	0	2	1
9	LC	ME-22005	CAD and Digital Manufacturing Lab	0	0	2	1
			Total	**15**	**00**	**04**	**16**
			Total Academic Engagement and Credits	**19**			**16**

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

VIII-Semester: [M-Group]: Scheme A

Sr. No	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	DEC		Department Elective-III [Option among minimum 3 courses]	3	0	0	3
2	DEC		Department Elective-IV [Option among minimum 3 courses]	3	0	0	3
5	SBC		Major Project	0	0	16	8
			Total	**06**	**00**	**16**	**14**
			Total Academic Engagement and Credits	**22**			**14**

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

VII-Semester: [M-Group]: Scheme B

Sr. No	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	MLC		Intellectual Property Rights	1	0	0	0

2	LLC		Liberal Learning Course	1	0	0	1
3	IOC		Interdisciplinary Open Course-II	2	0	0	2
4	DEC		Department Elective-II [Option among minimum 3 courses]	3	0	0	3
5	PCC	ME-22001	Automatic Control System	3	0	0	3
6	PCC	ME-22002	Refrigeration and Air Conditioning	3	0	0	3
7	PCC	ME-22003	CAD and Digital Manufacturing	2	0	0	2
8	LC	ME-22004	Refrigeration and Air Conditioning Lab	0	0	2	1
9	LC	ME-22005	CAD and Digital Manufacturing Lab	0	0	2	1
			Total	**15**	**00**	**04**	**16**
			Total Academic Engagement and Credits	**19**			**16**

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

VIII-Semester: [M-Group]: Scheme B

Sr. No	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	SBC		Internship and Major Project with Industry/Corporate/Academia	0	0	16	8
2	SLC		Massive Open Online Course -I	3	0	0	3
3	SLC		Massive Open Online Course -II	3	0	0	3
			Total	**06**	**00**	**16**	**14**
			Total Academic Engagement and Credits	**22**			**14**

VII-Semester: [M-Group]: Scheme C

Sr. No	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	MLC		Intellectual Property Rights	1	0	0	0
2	LLC		Liberal Learning Course	1	0	0	1
3	IOC		Interdisciplinary Open Course-II	2	0	0	2
4	DEC		Department Elective-II [Option among minimum 3 courses]	3	0	0	3
5	PCC	ME-22001	Automatic Control System	3	0	0	3
6	PCC	ME-22002	Refrigeration and Air Conditioning	3	0	0	3
7	PCC	ME-22003	CAD and Digital Manufacturing	2	0	0	2
8	LC	ME-22004	Refrigeration and Air Conditioning Lab	0	0	2	1
9	LC	ME-22005	CAD and Digital Manufacturing Lab	0	0	2	1
			Total	**15**	**00**	**04**	**16**
			Total Academic Engagement and Credits	**19**			**16**

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

VIII-Semester: [M-Group]: Scheme C

Sr. No	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	SBC		Internship and Major Project with Non domain organization	0	0	16	8
2	SLC		Massive Open Online Course -I	3	0	0	3
3	SLC		Massive Open Online Course -II	3	0	0	3
			Total	**06**	**00**	**16**	**14**
			Total Academic Engagement and Credits	**22**			**14**

- ONE Minor course [To be offered to the Students from Other Departments]
- ONE Honors course [To be offered to Students of Host Department]

List of Departmental Electives II (Semester VII):

Sr. No.	Course Code	Elective Course	Sr. No.	Course Code	Elective Course
1	ME (DE)-22001	Power Plant Engineering	6	ME (DE)- 22006	Molecular Mechanics and Multi Scale Modeling
2	ME (DE)-22002	Hybrid and Electric Vehicle	7	ME (DE)- 22007	Robotics and Automation
3	ME (DE)-22003	Solar Energy Engineering and Systems	8	ME (DE)- 22008	Industrial Engineering
4	ME (DE)-22004	Integrated Product Design	9	ME (DE)- 22009	Mechatronics and IoT
5	ME (DE)-22005	Failure Analysis and Prevention			

List of Departmental Electives III (Semester VIII):

Sr. No.	Course Code	Elective Course	Sr. No.	Course Code	Elective Course
1	ME (DE)-2200X	Energy Conservation and Management	6	ME (DE)-	Condition Monitoring
2	ME (DE)-2200X	Heating Ventilation Air Conditioning and Refrigeration	7	ME (DE)-	AI & ML For Mechanical Engineers
3	ME (DE)-2200X	Connected and Autonomous Vehicle	8	ME (DE)-	Sensors and Actuators in Robotics Technology
4	ME (DE)-2200X	Computational Convective Heat Transfer	9	ME (DE)-	Project Management
5	ME (DE)-2200X	Mechanics of Composite Materials			

List of Departmental Electives IV (Semester VIII):

Sr. No.	Course Code	Elective Course	Sr. No.	Course Code	Elective Course
1	ME (DE)-	Design of Heat Exchanger	5	ME (DE)-	Mechanical Vibrations and Acoustics
2	ME (DE)-	Introduction to Nuclear Engineering	6	ME (DE)-	Tribology
3	ME (DE)-	Nano Technology in Solar Engineering	7	ME (DE)-	Advanced CAD/CAM
4	ME (DE)-	Fracture Mechanics	8	ME (DE)-	Manufacturing Philosophies

Minor and Honor courses (VII-Semester)

Sr. No.	CourseType	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	Minor: Product Design and Optimization	ME (MI)-XX001	Introduction to Optimization Techniques	3	0	0	3
1	Honor: Hybrid and Electric vehicle	ME (HO)-XX001	Hybrid and Electric Vehicles	3	0	0	3
2	Honor: Thermal Stream	ME (HO)-XX002	Advanced Heat Transfer	3	0	0	3
3	Honor: Design Stream	ME (HO)-XX003	Stress Analysis	3	0	0	3

Minor and Honor courses (VIII Sem)

Sr. No.	CourseType	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	Minor: Product Design and Optimization	ME (MI)-XX002	Introduction to CAD/CAM	3	0	0	3
1	Honors: Hybrid and Electric vehicle	ME (HO)-XX004	Automotive Transmission and Control	3	0	0	3
2	Honor: Thermal Stream	ME (HO)-XX005	Modeling of IC Engines	3	0	0	3
3	Honor: Design Stream	ME (HO)-XX006	Advanced Vibration and Acoustics	3	0	0	3

Interdisciplinary Open Course-II (IOC-II)

Sr. No.	Course Code	IOC-II
1	ME (IOC) XX001	Air Conditioning

Departmental Elective- II

ME (DE) 22001 Power Plant Engineering

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Explain the basic working principles of steam, hydel, diesel, as turbine power plant and boilers.
- Evaluate performance of thermal power plant, hydel power plant, diesel power plant gas turbine power plant.
- Illustrate working principle of diferent types of nuclear power plant.
- Describe working and significance of various non-conventional power plants.
- Evaluate cycle efciency and performance of these power plants.
- Know the costs associated with power generation.
- Evaluate economics of plant selection and generation.
- Appraise safety aspects of power plants.

Unit 1 **(6 hrs)**

Introduction to Power Plants & Boilers:
Layout of steam, hydel, diesel, mhd, nuclear and gas turbine power plants, combined power cycles, comparison and selection, load duration curves, steam boilers and cycles, high pressure and super critical boilers, fluidised bed boilers.

Unit 2 **(6 hrs)**

Steam Power Plant:
Fuel and ash handling, combustion equipment for burning coal, mechanical stokers, pulveriser, electrostatic precipitator, draught,diferent types, surface condenser types, cooling towers.

Unit 3 **(6 hrs)**

Hydel Power Plants:
Hydel power plant, essential elements, selection of turbines, governing of turbines- micro hydel developments.

Unit 4 **(6 hrs)**

Diesel and Gas Turbine:
Types of diesel plants, components, selection of engine type, applications gas turbine power plant, fuels, gas turbine material, open and closed cycles, reheating, regeneration and inter-cooling, combines cycle.

Unit 5 **(6 hrs)**

Other Power Plants:
Nuclear energy, fission, fusion reaction, types of reactors, pressurized water reactor, boiling water reactor, waste disposal and safety. geo thermal, otec, tidal, pumped storage, solar central receiver system.

Unit 6 **(6 hrs)**

Economics of Power Plants:
Cost of electric energy, fixed and operating costs, energy rates, types tarifseconomics of load sharing, comparison of various power plants.

Text Books:

- Arora S.C and Domkundwar S, "A Course in Power Plant Engineering", DhanpatRai, 2016.
- Nag P.K ,"Power Plant Engineering" Third edition Tata McGrawHill,2014.

Reference Books:

- EI-WakilM.M ,Power "Plant Technology," Tata McGraw-Hill 2017.
- K.K.Ramalingam , " Power Plant Engineering ", Scitech Publications, 2015.
- G.R,Nagpal , "Power Plant Engineering", Khanna Publishers 2011.
- G.D.Rai, "Introduction to Power Plant Technology" Khanna Publishers,2015.
- Black & Veatch, "Power Plant Engineering", Springer Science & Business Media, Inc 1996.

Departmental Elective- II
ME (DE) 22002 Hybrid and Electric Vehicle

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- Apply basic principles of hybrid and electric vehicle to design vehicle.
- Select appropriate cycle source of energy for the hybrid electric vehicle based on driving.
- Analyze the power and energy need of the various hybrid electric vehicle.
- Measure and estimate the energy consumption of the Hybrid Vehicles.
- Evaluate energy efficiency of the vehicle for its drive trains.

Unit 1 **(6 hrs)**

Introduction to Electric Vehicle:
History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.

Unit 2 **(6 hrs)**

Induction to Hybrid Electric Vehicle:
Social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies. Hybrid Electric drivetrains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Unit 3 **(8hrs)**
Electric Drive Trains:
Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit 4 **(7hrs)**

Types of Storage Systems:
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Calculation for the ratings.

Unit 5 **(7hrs)**

Modelling of Hybrid Electric Vehicle Range:
Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2-wheeler, 3-wheeler and 4-wheeled vehicles.

Unit 6 **(7hrs)**

Energy Management Strategies
Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Introduction to various charging techniques and schematic of charging stations.

Reference Books:

- James Larminie, J. Lowry, "Electric Vehicle Technology Explaned", John Wiley & Sons Ltd. 2003.
- M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, "Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design", CRC Press, 2004.
- S. Onori, L. Serrao and G. Rizzoni, "Hybrid Electric Vehicles: Energy Management Strategies",Springer, 2015.
- Iqbal Hussein, "Electric and Hybrid Vehicles: Design Fundamentals", CRC Press, 2003.

List of Open-Source Software/learning website:

- Online course: https://nptel.ac.in/course.html
- Ocw.mit.edu/courses
- https://www.eng.mcmaster.ca/mech/content/electric-and-hybrid-vehicles

Departmental Elective- II
ME (DE) 22003 Solar Energy and Engineering System

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Describe the equipments used for the measurement of solar irradiation
- Estimate the type of solar collector needed for the application

- Evaluate and analyze the performance of solar thermal system utilizing the suitable model
- Apply the concepts of semiconductors on the solar photovoltaic

Unit 1 **(5 hrs)**

Solar radiation and measurement:
Solar constant, spectral distribution and variation of extra terrestrial radiation, definitions of irradiations, solar angles, angles of tracking surfaces, ratio of beam radiation on tilted surface to horizontal surface, shading, short wave and long wave radiation, pyrheliometer and pyranometer, shading ring, solar radiation data, atmospheric attenuation of solar radiation.

Unit 2 **(8 hrs)**

Preliminary heat transferand radiation characteristics:
Basic radiative laws, radiation intensity and flux, relationships among Absorptance, emittance and reflectance, sky radiations, natural convection between flat parallel plates, wind convection coefficient, selective surfaces, mechanism of selectivity, specularly reflecting surfaces, absorption by glazing, optical properties of cover systems, transmittance - Absorptance product

Unit 3 **(6 hrs)**

Non concentrating solar thermal collectors:
Description of flat plate collectors, energy balance of flat plate collector, temperature distribution in flat plate collector, overall heat loss coefficient, effect of dust and shading, liquid heat plate geometries, air heaters, collector characterization, practical considerations for flat plate collectors,

Unit 4 **(7 hrs)**

Concentrating solar thermal collectors:
Concentration ratio, thermal performance of concentrating collector, optical performance of concentrating collectors, optical characteristics of non imaging concentrators, orientation and absorbed energy for CPC collectors, performance of CPC collectors, Ray tracing methods for evaluating concentrators, paraboloidal concentrators, central receiver collectors

Unit 5 **(8 hrs)**

Energy storage and Economics:
Process load and solar collector outputs, energy storage in solar process system, water storage, stratification in storage tanks, phase change energy storage, chemical energy storage.
Cost of solar process system, design variables, economic figures of merit, discounting and inflation, life cycle saving method

Unit 6 **(8 hrs)**

Solar Photovoltaic:

Fundamental of semi-conductor physics, doping, interaction of light and semi-conductors, functioning of solar cells, types of solar cells, efficiency measurements, recent developments in solar cells, Characteristic curves of PV system technology, basics of load calculations, applications of solar photovoltaic.

Text books:

- Duffie, J.A. and Beckmann, W.A., Solar Engineering of Thermal Processes, John Wiley &Sons (2006).
- Sukhatma, S and Nayak, J., Solar Energy Principle of Thermal Collection and Storage, McGraw-Hill (2009).
- Garg, H.P. and Prakash, J., Solar Energy: Fundamentals and Applications, Tata McGraw Hill (2000).

Reference books:

- Kalogirou, A.S., Solar Energy Engineering: Processes and Systems, Academic Press Inc. (2014).
- Goswami, D.Y., Kreith, F. and Kreider J., Principles of Solar Energy, Taylor & Francis (2003).
- Chetan Singh Solanki, Solar photovoltaic fundamental technologies and applications, PHI publications (2015)

Departmental Elective- II
ME (DE) 22004 Integrated Product Design

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- Identify the needs of the customer while designing a new product or while modifying existing design of a product in the highly competitive, dynamic and customer centered market.
- Convert the needs of customers in technical specifications and constraints of a product.
- Design the products after realizing the importance of creativity.

- Employ the learnings of various rapid prototyping methods and reverse engineering methods for generating and testing the new product designs.
- Apply principles of statistical considerations in design
- Realize the importance of design for manufacture and assembly and apply the principles to the design.
- Utilize the principles of maintenance&reliability for the design.

UNIT 1: **(12 Hrs)**
Need Identification and problem definition, product specification, concept generation and selection, evaluation, creativity methods, Concept testing

UNIT 2: **(8 Hrs)**
Design for manufacture and assembly, robust design , concurrent engineering,

UNIT 3: **(6 Hrs)**
Rapid prototyping and reverse engineering

UNIT 4: **(6 Hrs)**
Statistical considerations in design

UNIT 5: **(4 Hrs)**
Strength based reliability, parallel and series systems

UNIT 6: **(3 Hrs)**
Ergonomics & Human behaviour in Design

Text Books

- Product Design Creativity, Concepts and Usability; Prashant Kumar, PHI Learning Pvt. Ltd. New Delhi, 2012
- "Engineering Design", George E Dieter, McGraw Hill Company, 2000.
- Reverse Engineering an Industrial perspective, Editors: Vinesh Raja, KiranJ.Fernandes, Springer , 2008
- Rapid Prototyping: Laser-Based and Other Technologies Patri K. Venuvinod, Weiyin Ma Springer, 30-Nov-2003
- Design of Machine Elements, V. B. Bhandari , Tata McGraw Hill Publications.2003

Reference Books

- Product Design and Development, Karl Ulrich, Steven Eppinger, 7th edition, McGraw Hill, 2020

Departmental Elective- II
ME (DE) 22005 Failure Analysis and Prevention

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Specify the diverse factors that cause mechanical failures.
- Identify the different facture modes and their characteristics.
- Identify failure mechanisms.
- Apply the procedures to conduct a failure analysis investigation due to different loading conditions.

Unit 1: (6hrs)
Introduction to Failure Analysis
Definition of failures, Classification of failures, Instantaneous failures, Cumulative failures, Fundamental causes of failures-Deficiencies in design, Deficiencies in selection of materials, Imperfection in materials, Deficiencies in processing techniques, Errors in assembly, Improper service conditions. Objectives of Failure analysis, Step by step procedure for Metallurgical failure analysis,

Unit 2: (6hrs)
Fracture
Details of Fractographic, Crack initiation and propagation in ductile and brittle material, Fracture types, Brittle fractures, Ductile fractures, Fatigue fractures, Cleavage and intergranular fractures, Griffith theory, Irwin’s modification, surface and embedded cracks, Surface treatments to minimize the surface cracks, Crack growth mechanism for plane stress and plain strain, Notch sensitivity, stress tri-axiality, Failure due to tension and torsion, Modulus of rupture, stress intensity factor, Fatigue crack growth, striations, identifications and remedies.

Unit 3: (6hrs)
Wear Failures
Definition of wear, Types of wear-adhesive wear, Abrasive wear, Corrosive wear, Erosive wear, fretting wear, Fatigue wear, Wear failure mechanisms and Preventive techniques. Failure of fraction surfaces: failure of clutches, Failure of brakes, Failure of seals, Creep failures, Stages of creep, Creep curve, Stress rupture,Failure modes and Preventive techniques of friction surface and Seals.

Unit 4: (6hrs)
Environment Induced Failures
Corrosion damage, Forms of corrosion-Uniform attack, Two metal corrosion or galvanic corrosion, Crevice corrosion, Pitting corrosion, Inter-granular corrosion, Selective leaching, Erosion corrosion, Corrosion cracking- Stress Corrosion Cracking, Corrosion fatigue, Hydrogen cracking, Hydrogen degradation, Liquid metal embrittlement, High temperature corrosion, corrosion failure mechanisms and Preventive techniques.

Unit 5: (6hrs)
Tools for Failure Analysis

Microscopic examination-Metallurgical Microscope, Scanning Electron Microscope, Transmission Electron Microscope, Physical testing-Tension test, Hardness test, Impact test, Fatigue test Non-Destructive Testing techniques-Magnetic particle inspection, Radiography, Liquid penetrant inspection, Eddy current testing, Ultrasonic testing, Acoustic Emission Testing, Thermography, Chemical analysis- Spectroscopy, Atomic absorption spectroscopy, Atomic emission spectroscopy.

Unit 6: (6hrs)
Problem Solving Techniques and Case Studies
Problem solving tools like Root cause analysis, cause and effect matrix, fishbone diagram, PDCA: Plan-Do-Check-Act Cycle, SCRA: Symptom, Cause, Remedy and Action system for solving acute and/or temporary problems / Quality Story, CEDAC: Cause-and-effect Diagram with Addition of Cards for chronic problems, etc., 8D (8 Disciplines), FMEA, etc.Failure investigations of rotating components- crack shaft, bearing and gears, boiler tube, turbine rotor, blades, aircraft fuselage, fasteners, Failures of cast, forged and welded components, etc.

Text Books

- Charlie R. Brooks and Ashok Chaudhary, Failure Analysis of Engineering Materials, McGraw Hill, New York.
- A.K. Das, Metallurgy of Failure Analysis, McGraw Hill, New York.

Reference Books

- ASM Handbook, Failure Analysis and Prevention, Edited by, ASM Publications, Vol. 11, 2002.
- Colangelo Vito J. and Heiser F., Analysis of Metallurgical Failures, Second Edition, John Wiley & Sons, Inc., 1987.
- Jones D. R. H., Failure Analysis and Case Studies, Elsevier Publications, 1998.
- Donald J. Wulpi, Understanding How Components Fail, ASM international.
- V. Ramachandran, Failure Analysis of Engineering Structures: Methodology and Case Histories, ASM International, Technology & Engineering, 2005.
- Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons, Fifth Edition.
- SAE J1739, “Potential Failure Mode and Effects Analysis in Design (Design FMEA)”

Departmental Elective- II
ME (DE) 22006 Molecular Mechanics and Multiscale Modeling

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Deal with molecular dynamics simulations at the nano-scale level and perform bottom-up approach in an efficient way.
- Perform FEM simulations at macro-scale by using nano-scale mechanical properties.
- Use the knowledge of fracture at nano-scale as well as macro-scale.
- Deal with interdisciplinary field problems, e.g nano-scale MD simulations and macro-scale FEM simulations
- Use the knowledge to explore naturally available hierarchical materials, which outperform artificial materials in terms of mechanical properties
- Apply contents of the lecture to natural as well as artificial materials.

Unit 1(04 Hrs)

Introduction and motivation of multi-scale modelling:
Need of multi-scale modelling, current and potential applications, future scope of multiscale modelling in research and development, challenges.

Unit 2 (08 hrs)

Theoretical background of molecular dynamics:
Basic molecular dynamics algorithm, potential energy, non-bonded interactions: van der Waals interactions, electrostatic interactions, embedded-atom method , Bonded interactions : covalent, Integration Algorithms : verlet Algorithm, velocity verlet Algorithm, predictor-corrector.

Unit 3 (08 hrs)

Common statistical ensembles and temperature couplings:
Common statistical ensembles: microcanonical (NVE); canonical (NVT); Isothermal-Isobaric (NPT), Ensemble: advantages, limitations and usages, Temperature couplings: velocity scaling; Berendsen; Andersen; and Nosé-Hoover, Temperature couplin : advantages, limitations and usages

Unit 4 (08 hrs)

Molecular dynamics simulations and mechanical properties at nanoscale
Initialization: crystal structure, initial atom velocities, Energy minimization: Steepest descent (SD), conjugate gradient (CG), Newton-Raphson, Equilibration : different types of equilibration, importance, influence on the output , Extration of mechanical properties : Virial stress, force, response functions (for example, constant volume heat capacity), entropic properties, radial distribution function , Non-equilibrium molecular dynamics : Calculate viscosity, thermal conductivity

Unit 5 (06 hrs)

Theoretical background of continuum mechanics:

Concept of a continuum, kinematics : motion and deformation , Governing equations Simple examples : tensile, compression, bending tests.

Unit6 **(06 hrs)**

Multiscalemodelling: bottom-up approach:
Scale bridging, Bottom-up approach, Applications, Analysis of multi-phasic materials, Examples of advanced materials, understanding of extraordinary properties of hierarchical materials, e.g., spider silk, nacre.

Text Books:

- Frenkel, D., and Smit, B. (2001). Understanding molecular simulation: from algorithms to applications (Vol. 1). Elsevier.
- Rapaport, D. C. (2004).The art of molecular dynamics simulation.Cambridge university press.
- Leach, A. R., and Leach, A. R. (2001). Molecular modelling : principles and applications. Pearson education

References:

- Allen, M. P. (2004). Introduction to molecular dynamics simulation. Computational soft matter : from synthetic polymers to proteins, 23(1), 1-28.
- Engquist, B., Lötstedt, P., Runborg, O. (Eds.). (2009). Multiscalemodeling and simulation in science (Vol. 66). Springer Science Business Media.
- Patil, S. P., Heider, Y., Padilla, C. A. H., Cruz-Chu, E. R., and Markert, B. (2016). A comparative molecular dynamics-phase-field modeling approach to brittle fracture. Computer Methods in Applied Mechanics and Engineering, 312, 117-129.
- Patil, S.P, Shendye, P, and Markert, B. (2020). Molecular dynamics simulations of silica aerogel nanocomposites reinforced by glass fibers, graphene sheets and carbon nanotubes. A comparison study on mechanical properties. Composites Part B Engineering, 107884.
- Raj, M., Patil, S. P., and Markert, B. (2020). Mechanical Properties of Nacre-Like Composites: A Bottom-Up Approach. Journal of Composites Science, 4(2), 35.
- Herman J.Govednik, M. Patil, S.P. and Markert, B. (2020). Molecular Dynamics Simulation Study of the Mechanical Properties of Nanocrystalline Body-Centered Cubic Iron. Surfaces, 3(3), 381–391.

Departmental Elective- II
ME (DE) 22007 Robotics and Automation

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- To understand basic terminologies and concepts associated with Robotics and Automation
- To study various Robotic sub-systems and Automation systems
- To study kinematics and dynamics to understand exact working pattern of robots
- To study the associated recent updates in Robotics and Automation

Unit 1 **(5 hrs)**

Introduction:
Basic concepts such as Definition , three laws, DOF, Misunderstood devices.....etc. , Elements of Robotic Systems i.e. Robot anatomy, Classification, Associated parameters i.e. resolution, accuracy, repeatability, dexterity, compliance, RCC device, ..etc,

Automation:
Concept, Need, Automation in Production System, Principles and Strategies of Automation, Basic Elements of an Automated System, Advanced Automation Functions, Levels of Automations, introduction to automation productivity.

Unit 2 **[05 hrs]**

Robot Grippers:

Types of Grippers , Design aspect for gripper, Force analysis for various basic gripper system.

Sensors for Robots:

Characteristics of sensing devices, Selections of sensors, Classification and applications of sensors.Types of Sensors, Need for sensors and vision system in the working and control of a robot.

Unit 3 **[06 hrs]**

Drives:

Types of Drives, Actuators and its selection while designing a robot system. Types of transmission systems,

Control Systems:

Types of Controllers, Introduction to closed loop control

Control Technologies in Automation:

Industrial Control Systems, Process Industries Verses Discrete-Manufacturing Industries, Continuous Verses Discrete Control, Computer Process and its Forms. Control System Components such as Sensors, Actuators and others.

Unit 4 **[07 hrs]**

Kinematics:

Transformation matrices and their arithmetic, link and joint description, Denavit - Hartenberg parameters, frame assignment to links, direct kinematics, kinematics redundancy, kinematics calibration, inverse kinematics, solvability, algebraic and geometrical methods.

Velocities and Static forces in manipulators:

Jacobians, singularities, static forces, Jacobian in force domain.

Dynamics:

Introduction to Dynamics , Trajectory generations

Unit 5 **[07 hrs]**

Machine Vision System:

Vision System Devices, Image acquisition, Masking, Sampling and quantisation, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation.

Robot Programming:

Methods of robot programming, lead through programming, motion interpolation, branching capabilities, WAIT, SIGNAL and DELAY commands, subroutines.

Programming Languages:

Introduction to various types such as RAIL and VAL II ...etc, Features of each type and development of languages for recent robot systems.

Unit 6 **[06 hrs]**

Modeling and Simulation for manufacturing Plant Automation:

Introduction, need for system Modeling, Building Mathematical Model of a manufacturing Plant, Modern Tools- Artificial neural networks in manufacturing automation, AI in manufacturing, Fuzzy decision and control, robots and application of robots for automation.

Artificial Intelligence:

Introduction to Artificial Intelligence, AI techniques, Need and application of AI.

Other Topics in Robotics:

Socio-Economic aspect of robotisation. Economical aspects for robot design, Safety for robot and associated mass, New Trends & recent updates in robotics

Text Books:

- John J. Craig, Introduction to Robotics (Mechanics & Control), Addison-Wesley, 2nd Edition, 2004
- Mikell P. Groover., Industrial Robotics: Technology, Programming & Appl., McGraw – Hill International, 1986.
- Shimon Y. Nof , Handbook of Industrial Robotics , , John Wiley Co, 2001.
- Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
- Industrial Automation : W.P. David, John Wiley and Sons.

Reference Books:

- Richard D. Klafter , Thomas A. Chemielewski, Michael Negin, Robotic Engineering : An Integrated Approach , Prentice Hall India, 2002.
- Handbook of design, manufacturing &Automation : R.C. Dorf, John Wiley and Sons.

Departmental Elective- II
ME (DE) 22008 Industrial Engineering

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:
- Apply the Industrial Engineering concept in the industrial environment.
- Manage and implement different concepts involved in methods study and understanding of work content in different situations.
- Undertake project work based on the course content.
- Describe different aspects of work system design and facilities design pertinent to manufacturing industries.
- Identify various cost accounting and financial management practices widely applied in industries.
- Develop capability in integrating knowledge of design along with other aspects of value addition in the conceptualization and manufacturing stage of various products.

Unit I: Introduction to Industrial Engineering and Productivity

Introduction: Definition and Role of Industrial Engineering, Contribution of Taylor and Gilbreth, Organisation : Concept of organisation, characteristics of organisation, elements of organisation, organisational structure, organisation charts; Types of organisation- formal line, military organisation, functional organization, line & staff organisation; Introduction to management principles, authority and responsibility, span of control, delegation of authority. Productivity : Definition of productivity, Productivity of materials, land, building, machine and power. Measurement of productivity: factors affecting the productivity, Productivity Models and Index (Numerical), productivity improvement programmers. [6 hrs]

Unit II: Method Study

Work Study : Definition, objective and scope of work-study. Human factors in work-study. Method Study : Definition, objective and scope of method study, activity recording and exam aids, Charts to record moments in shop - operation process charts, flow process charts, travel chart, two handed chart and multiple activity charts. Charts to record movement at work place - principles of motion economy, classification of moments, SIMO chart, and micro motion study. Definition and installation of the improved method, brief concept about synthetic motion study and related Numricals. [6 hrs]

Unit III: Work Measurements

Work Measurements: Definition, objectives and uses; Work measurement techniques. Work sampling - need, confidence levels, sample size determinations, random observation, conducting study with the simple problems. Time study: Definition, time study equipment, selection of job, steps in time study. Breaking jobs into elements, recording information. Rating and standard rating, standard performance, scales of rating, factors affecting rate of working, allowances and standard time determination; Introduction to PMTS and MTM. (Numerical), Introduction to MOST [6Hrs]

Unit IV: Production Planning and Control

Introduction: Types of production systems, Need and functions of PPC, Aggregate production planning, Capacity Planning, ERP: Modules, Master Production Schedule; MRP and MRP-II; Forecasting techniques: Causal and time series models, moving average, exponential smoothing, trend and seasonality; (Numerical). [6 hrs]

Unit V: Facility Design

Facility Location Factors and Evaluation of Alternate Locations; Types of Plant Layout; Computer Aided Layout Design Techniques; Assembly Line Balancing (Numerical); Material Handling: Principles, Types of Material Handling Devices;) Industrial Safety: Safety Organisation, Safety Programme, General Safety Rules. Stores Management.[6 hrs]

Unit VI: Engineering Economy

Engineering Economy and Costing: Elementary Cost Accounting and Methods of Depreciation; Breakeven Analysis (Numerical).Inventory Control: Functions, costs, classifications- Concept of EOQ, purchase model without shortages (Numerical); ABC ,VED and other Analysis [6 hrs]

Text Books:

- M Mahajan, “Industrial Engineering and Production Management”, DhanpatRai and
- Co,2015.

- O. P. Khanna, "Industrial engineering and management", DhanpatRai publication, ISBN no 13-978- 8189928353, 2010
- MartendTelsang, "Industrial Engineering", S. Chand Publication, ISBN no 13-978-8121917735,2006.
- Banga and Sharma, "Industrial Organisation & Engineering Economics", Khanna publication, ISBN no 13- 978-8174090782, 2003.

Reference Books:

- Introduction to Work Study by ILO, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
- H.B. Maynard, K Jell, "Maynard's Industrial Engineering Hand Book", McGraw Hill Education.
- Askin, "Design and Analysis of Lean Production System", Wiley, India
- Zandin K.B., "Most Work Measurement Systems", CRC Press,2002
- Martin Murry, "SAP ERP: Functionality and Technical Configuration", SAP Press; 3rd New edition (2010).
- Barnes, "Motion and time Study design and Measurement of Work", Wiley India

Departmental Elective- II
ME (DE) 22009 Mechatronics and IoT

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Define key elements of mechatronics, principle of sensor and its characteristics
- Utilize concept of signal processing & interface systems such as ADC, DAC, Digital I/O
- Determine the transfer function by using block diagram reduction technique
- Evaluate Poles/Zero, frequency domain parameter for modelling of mechanical system
- Apply the concept of different controller modes to an industrial application
- Develop the ladder programming for industrial application

Unit 1: Introduction to mechatronics, Sensors, Actuators [10 Hrs.]
Introduction to Mechatronics, Need, Applications, building blocks of a typical mechatronic system, Sensors: Types of sensors; Motion Sensors – Encoder (Absolute & incremental), Lidar, Eddy Current, Proximity (Optical, Inductive, Capacitive), MEMS Accelerometer; Temperature sensor – Thermocouple, Thermistor, RTD, Pyrometer, Infrared Thermometer; Force / Pressure Sensors – Strain gauges, Piezoelectric sensor; Flow sensors – Electromagnetic, Ultrasonic, Hot-wire anemometer; Colour sensor – RGB type; Biosensors – Enzyme, ECG, EMG, Selection of Sensors, Actuators: Stepper & Servo motor; Hydraulic and Pneumatic; linear electrical actuators & Selection of Actuators

Unit 2: Introduction to IOT [05 Hrs.]

Introduction of IoT: Definition and characteristics of IoT, Technical Building blocks of IoT, Device, Communication Technologies, Data, Physical design of IoT, IoT enabling technologies, IoT Issues and Challenges- Planning, Costs and Quality ,Security and Privacy, Risks

Unit 3: Data Acquisition and Embedded Systems [10 Hrs.]
Introduction to DAQ, Types, Components of a Data Acquisition System (Sensor, Signal conditioning, processing, controlling and storage/display/action), Data Acquisition: Signal collection, Signal conditioning – Isolation& Filtering, Amplification, Sampling, Aliasing, Sample and hold circuit, Quantization, Analog-to-digital converters (4 bit Successive Approximation type ADC), Digital-to-Analog converters (4 bit R2R type DAC), Data storage, Embedded Systems: Architecture & Characteristics of ES, Types of Embedded systems, Examples of Embedded Systems. Embedded System on Chip (SOC), Components of ES: Hardware and software Hardware components of ES: Power supply: types, characteristics, selection criteria, Processing Unit, Input devices, Output Device.

Unit 4: Communication under IoT [05 Hrs.]
Development boards: Types of boards - Arduino, Raspberry pi, Beagle bone, ESP8266, selection criteria, interfacing of sensors with development boards. Communication under IoT: IoT Protocols: MQTT, CoAP, XMPP and AMQT, IoT communication models, IoT Communication technologies: Bluetooth, BLE, Zigbee, Zwave, NFC, RFID, LiFi, Wi-Fi, Interfacing of wifi, RFID, Zigbee,NFC with development board

Unit 5: PLCs and PID controllers [8 Hrs.]
Introduction to controllers, Need for Control, Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; (Numerical approach), Feed forward anticipatory control, Manual tuning of PID control, Ziegler–Nichols method, Applications: Electro–Hydraulic/Pneumatic Control, Automotive Control
Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counters; Practical examples: Ladder Programming, Functional Block Diagram.

Unit 6: Machine Learning for IOT and IOT Security [07 Hrs.]
Compact fast Machine Learning Accelerators for IOT devices: Edge Computing on IOT Devices, IOT Based Smart Buildings, Distributed Machine Learning, Machine Learning Accelerator, Machine Learning Model Optimization, Least-Squares-Solver for Shallow Neural Network: Introduction, Algorithm Optimization, Hardware Implementation
Securing the Internet of Things & Security Architecture, Security and Vulnerability in the Internet of Things, IoT Node Authentication, Data Protection & Security Requirements in IoT Architecture, Security in Enabling Technologies & Existing Security Scheme for IoT, Introduction to the Use Cases and Emerging Standards and Technologies for Security and privacy in IoT

Text Books:

- William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019
- K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008
- Bolton, Programmable Logic Controller, 4th Ed, Newnes, 2006
- Lyla B. Das, “Embedded Systems: An Integrated Approach” Pearson

- Raj Kamal, “Embedded Systems: Architecture, programming and Design”, 2nd Edition, McGrawHill, ISBN: 13: 9780070151253
- Raj Kamal, Internet of Things: Architecture and Design Principle” , ISBN-13: 978-93-5260-522-4, McGraw Hill Education (India) 2017
- Securing the Internet of Things, Shancang Li Li Da Xu, Syngress, 2017, Elsevier

References Books:

- Alciatore&Histand, Introduction to mechatronics & measurement systems, 5^{th} Ed, 2019
- Bishop (Editor),Mechatronics – An Introduction CRC 2006
- Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill
- C. D. Johnson, Process Control Instrumentation Technology, Prentice Hall,New Delhi
- Sriram V. Iyer, Pankaj Gupta, “Embedded Real-time Systems Programming”, Tata McGraw-Hill, ISBN: 13: 9780070482845
- David Hanes, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, ISBN-13: 978-1-58714-456-1, ISBN-10: 1-58714-456-5, 2017
- Hantao Huang, Hao Yu, “Compact and Fast Machine Learning Accelerator for IoTDevices,”Edition: 1st ed. Publisher: Springer Singapore Year: 2019ISBN: 978-981-13-3323- 1

ME 22001 Automatic Control System

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Understand the basic contolconcepts, control actions and control systems.
- Find the transfer function for linear, time-invariant mechanical systems and produce analogous electrical, thermal and fluid-flow circuits/systems.
- Analyse quantitatively the transient response of first and second order systems.
- Apply frequency response techniques for stability analysis.
- Study of system in time & frequency domain and understand concept of stability.

(6hrs)

Unit 1: Introduction to Automatic Control System
Need of control system, Manual Vs. Automatic Control System, Advantages of Automatic Control System, Open Loop and Closed Loop Control System and their comparison, Concept of Feedback, Generalized Control System and concept of Transfer Function. Representation of Control System Components: Study of various types of control system components and their mathematical representation used in systems like Mechanical system, Electrical System, Thermal System, Fluid System, Grounded chair representation, Analogies,Block representation of System Elements, Block Diagram Algebra, Block Diagram Reduction

Unit 2: **(6 hrs)**
Transient Response Analysis
Transient and Steady State Response Analysis: Introduction, Various types of standard input signals, First order response to Step, Ramp and Impulse Input, Response of second order system to step input, 8 System specifications, Concept of time constant and its importance in speed response, Effect of Damping ratio on response of Second Order System.

Unit 3: **(6 hrs)**
Control Action and Controllers

Basic types of control action like ON/OFF, Proportional, Integral, Derivative type and their combinations (P,I,PI,PD and PID), Pneumatic and Hydraulic Controllers, Comparison of Pneumatic and Hydraulic Control System. Electrical Systems: Detail study of AC and DC Servo motors, Stepper motors, Servomechanism, Position Control System

Unit 4: **(6 hrs)**
Frequency Response Analysis and Root Locus Technique

Stability analysis, System Stability and Routh's Stability Criteria, Relative Stability Concepts, Polar plots, Phase and Gain Margin, Stability analysis using Bode plots, Simplified Bode plot Root Locus Plots: Definition of Root loci, General Rules for constructing Root Locus, Analysis using Root Locus Plots, Use of MATLAB software in control system.

Unit 5: MATLAB, SIMULINK and LABVIEW **(6 hrs)**

Application of MATLAB in Automatic Control, Dynamic system simulation and PID control using MATLAB and SIMULINK, Introduction to LABVIEW

Unit 6: Digital Control **(6 hrs)**
Introduction to digital/computer based measurement and control systems, Role of computers in process control, Basic components of computer based measurement and control system, sample and hold, ADC /DAC, Architecture of computer based control, Human Machine Interface (HMI), Interfacing computer system with process, Hardware and software of computer based process control system

Text Books :

- Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall of India,5thEdition, 2010.
- Norman S. Nise, "Control Systems Engineering", John Wiley & Sons, 6th Edition, 2010.
- Rudrapratap,"Getting srated with MATLAB",Oxford university press,12 th Edition,2009

Reference Books :

- Francis H. Raven, "Automatic Control Engineering", TMH, 5th edition, 1994.
- Benjamin and C.Kuo, Farid Golnaraghi, "Automatic Control Systems", John Wiley & Sons, 9th Edition, 2014.

ME 22002 Refrigeration and Air Conditioning

Teaching Scheme
Lectures: 2hrs / week
Tutorial: 1 hr / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Understand the working of Vapour Compression refrigeration system
- Design the Vapour Compression refrigeration system for various applications.
- Apply the knowledge of HVAC for multi-pressure systems.
- Able to understand and apply the Psychrometry for air conditioning applications.
- Able to design the duct for various air conditioning systems.

Unit 1: Refrigeration Systems (12 hrs)
Vapour Compression refrigerationsystem: A Refrigerating Machine, Types of refrigeration system, Vapour Compression refrigeration system and thermodynamic cycle, Effect of Evaporator Pressure, Effect of Condenser Pressure, Effect of refrigerant Superheating and Sub cooling, Actual Vapour Compression Cycle (Numerical treatment).
Vapour Absorption Refrigeration Systems: Introduction, working principle, aqua-ammonia, Lithium-bromide and Electrolux Systems.
Multipressure systems: Multi-evaporator Systems, Multistage Systems, Flash Gas Removal, Flash Intercooling, Choice of Intermediate Pressure, Complete Multistage Compression System, Multi-evaporator Systems, Cascade Systems, Solid Carbon Dioxide-Dry Ice, Manufacture of Solid Carbon Dioxide, System Practices for Multistage Systems (Numerical treatment)

Unit 2: Refrigerants (3hrs)
A Survey of Refrigerants, Designation of Refrigerants, Selection of a Refrigerant, Thermodynamic, Chemical, Physical, and safety Requirements, Secondary Refrigerants, Ozone depletion, Global warming, green house effect, Environment friendly refrigerant R134a, R410a, R600a, R290, R32. (Theoretical only)

Unit 3:Refrigerant Compressors (5hrs)
Types of Compressors, Thermodynamic Processes during Compression, Principal Dimensions of a Reciprocating Compressor, Performance Characteristics of a Reciprocating Compressor, Capacity Control of Reciprocating Compressors, Rotary Compressors, Screw Compressors, Centrifugal Compressors, Digital scroll compressors

Unit 4: Condensers, Evaporators and Expansion Devices (6hrs)

Construction and working, Types of condensers, evaporators and expansion devices, Capillary Tube and Its Sizing, pumps, heat exchangers etc. Work done and heat transfer during steady flow processes.

Unit 5: Psychometrics of Air – Conditioning Processes (8hrs)

Properties of moist Air, Working Substance in Air Conditioning, Psychometric Properties, Psychometric Chart, Mixing Process, Basic Processes in Conditioning of Air Psychometric Processes in Air – conditioning Equipment comfort conditions, (Numerical Treatment).

Unit 6:Load Calculation and Applied Psychrometrics(6hrs)
Preliminary Considerations, Internal Heat Gains, System Heat Gains, Break-up of ventilation Load and Effective Sensible Heat Factor, Cooling-load Estimate, Heating – load Estimate, Psychometric Calculations for Cooling, Design of air conditioning equipment, Numerical examples, Introduction to duct design by equal friction method.

Text Books

- Arora R.C., Refrigeration and Air Conditioning, PHI, India
- Dossat Ray J., Principal of Refrigeration, Pearson, India
- Arora C P, Refrigeration and Air Conditioning, Tata McGraw Hill
- Manohar Prasad, Refrigeration and Air-conditioning, Wiley Eastern Limited, 1983
- S.N. Sapali “Refrigeration and Air-conditioning”, PHI (Second Edition) 2016

Reference Books

- Threlkeld J.L., Thermal Environmental Engineering, Prentice Hall Inc. New Delhi
- ASHRAE Handbook (HVAC Equipments)
- Stocker W.F. and Jones J.W., Refrigeration and Air-conditioning, McGraw Hill International editions 1982.
- Roger Legg, Air conditioning systems: Design, Commissioning and maintenance
- Shan Wang, Handbook of Refrigeration and Air Conditioning, McGrawHill Publications
- Wilbert Stocker, Industrial Refrigeration, McGrawHill Publications
- Keith Harold, Absorption chillers and Heat Pumps, McGrawHill publications
- ASHRAE, Air Conditioning System Design Manual, IInd edition, ASHRAE.

ME 22003 CAD and Digital Manufacturing

Teaching Scheme
Lectures: 2hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:
- Recall the fundamentals of CAD/CAM
- Apply various 2-D and 3-D geometric transformations
- Represent 2-D/ 3-D analytic and synthetic entities and Compare solid-surface modeling
- Examine CNC program for production of components
- Express the principles and methods of Rapid Prototyping

Unit 1: **(3hrs)**

Fundamentals of CAD/CAM
Product cycle and scope of CAD/CAM/CIM in product cycle, Features of CAD/CAM Hardware and software, selection of software. CAD workstation configurations

Unit 2: (5hrs)
Geometric Transformation
Geometric verses coordinate transformations, 2D geometric transformations, Homogeneous co-ordinate representation, Composite transformations, 3D transformations, Inverse transformations, geometric mapping, Examples of transformation applications in mechanical engineering

Unit 3: (5hrs)
Representation of Curves and surfaces
Introduction to Analytic Curves: line, circle, ellipse, parabola, hyperbola, Synthetic Curves: Hermite Cubic Spline, Bezier Curve, B-Spline curve. Analytic and Synthetic Surface Representation

Unit 4: (4hrs)
Geometric Modeling
2D Vs 3D modeling, Comparison of Wireframe, surface and solid modeling techniques, Geometry Vs Topology, Requirements of Solid Modeling, Solid Modeling Methods: Constructive Solid Geometry (CSG), Boundary Representation (B-rep), etc.

Unit 5: (6hrs)
Computer Numerical Control and Part Programming
Introduction to NC/CNC/DNC machines, Classification of NC systems, Axis nomenclature, Interpolation, features of CNC controllers, Types of CNC machines, Construction features of CNC machines, Manual Part Programming, NC word format, Details of G and M codes, Canned cycles, subroutines and Do loops, Tool radius and length compensations. Exercises on CNC turning center and machining center programming

Unit 6: (3hrs)
Rapid Prototyping and Manufacturing
Introduction to Rapid Prototyping, rapid tooling and rapid manufacturing.Process of rapid prototyping.Different techniques of Rapid prototyping and their applications.

Text Books
- CAD/CAM Theory and Practice, Ibrahim Zeid, Tata McGraw-Hill Publishing Company Ltd.
- Mathematical Elements for Computer Graphics, Dacid F. Rogers, J Alan Adams, McGraw-Hill publishing Company Ltd.

Reference Books
- Geometric Modelling, M.E. Mortenson, Wiley, 2016
- Wolfe & Henderson Computer Aided Design & Manufacturing, Bedworth, McGraw Hill, 2003.

ME 22004 Refrigeration and Air Conditioning Lab

Teaching Scheme
Lectures: 2hrs / week

Examination Scheme
Term work: 50 marks
Practical / Oral: 50 marks

Course Outcomes:
At the end of the course students will be able to:

- Demonstrate the working of domestic refrigerator and Split Air conditioning systems.
- Estimate and analyze the cooling capacity, COP, Power of a VCR system.
- Determine the RSHF using Psychrometric chart.
- Analyze performance of Expansion devices in VCR system
- Estimate the cooling capacity of an evaporative air cooler.
- Demonstrate techniques of estimating building envelop load

List of Experiments:
The students should perform 8 experiments from the following list.

1. Demonstration of a domestic refrigerator along with different auxiliary systems associated with a refrigerator.
2. Trial on Vapour Compression Refrigeration System to determine cooling capacity and coefficient of performance.
3. Trial on Vapour Compression Refrigeration System with R290 as a refrigerant
4. Trial on Air conditioning test rig to determine cooling capacity and COP of VCR system.
5. Trial on Air conditioning test rig to study the psychrometric processes.
6. Trial on an Evaporative Air Cooler
7. Trial on Ice Plant, to determine Coefficient of Performance for ice plant test rig
8. Performance analysis of expansion devices at different operating conditions
9. Study of Vapour Absorption refrigeration Systems.
10. Design of cold storage with process layout
11. Building heat load simulation using suitable software (Trace 700, Energy plus etc.)

ME 22005 CAD and Digital Manufacturing Lab

Teaching Scheme
Lectures: 2hrs / week

Examination Scheme
Term work: 50 marks
Practical / Oral: 50 marks

Course Outcomes:
At the end of the course students will be able to:

- Design parametric models and assembly using CAD software.
- Develop CNC program and simulate.
- Distinguish various 3D printers and able to operate them.

List of Experiments:

1. Use of CAD software to create parametric 3-D models.

2. Use of CAD software to create assembly of components and generate drawings.
3. Manual part programming for CNC lathe machine.
4. Manual part programming for CNC milling machine.
5. Write a program to generate a curve/surface and apply transformation
6. Demonstration of 3D printers and scanners.

Departmental Elective- III
ME (DE) XX001 Energy Conservation and Management

Teaching Scheme	**Examination Scheme**
Lectures : 3hrs / week	Internal Test 1: 20 marks
Tutorial: 1 hr / week	Internal Test 2: 20 marks
	End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

1. Understand and Analyze national and international energy scenario
2. Calculate energy losses in process, equipment and plat etc.
3. Showcase energy conservation opportunities in various mechanical systems and suggest methods for energy savings
4. Analyze the energy data of industries and utilize the technical skills attained to carry out energy accounting and balancing
5. Perform energy audit and use energy management tools
6. Apply practices of energy conservation in various sectors like domestic, Industry and commercial

Unit 1: (6 hrs)

Introduction

Global Energy Scenario and Indian Energy Scenario in various sectors and Indian economy. Concerns of Energy Security in India

Basics – Revision of basics of Electrical and Mechanical Engineering relevant to Energy conservation and Management, Definitions of units, conversions in commercial practices Sankey Diagrams, Specific Energy consumption

Unit 2: (6 hrs)

Economic Analysis

Simple Payback Period, Return on Investment, Dynamic value of money, Discount Rate Cash flow, Time value of money, Formulae relating present and future cash flow - single amount, uniform series; Payback period; Return on Investment (ROI); Life Cycle cost. Costing of Utilities- specific costs of utilities like; all fuels stream, compressed air, electricity, water etc.

Unit 3: (6 hrs)

Energy Conservation Opportunities in Mechanical Systems
Compressed air systems, Refrigeration and air-conditioning system and water systems, Elementary coverage of Energy conservation in pumps and.
Cogeneration-concept, options(steam/gas, turbine/DCT-based), Selection criteria,

Unit 4: (6 hrs)

Energy Conservation Opportunities in Electrical Systems
Electric System Demand control, Demand Side Management (DSM), Power Factor Improvement, benefits and ways of improvement, Load scheduling, Electric motors, losses, efficiency, energy-efficient motors, motor speed control, variable speed drive. Lighting: Illumination levels, fixtures, timers, energy efficient illumination.

Unit 5: (6 hrs)

Energy Audit:
Energy Auditing Elements and concepts, Types of energy audits, methodology, Instruments used in energy auditing; Portable and On-line instruments; Role of Non Conventional Energy Sources in Energy Conservation; Need and Kyoto Protocol, Carbon Credits and Clean Development Mechanism (CDM).

Unit 6: (6 hrs)

Energy conservation in Buildings, Heating, Ventilation and Air Conditioning System,
Energy conservation in Boilers, Performance testing, efficiency and energy conservation opportunities
Energy conservation in Steam Systems– Aspects of steam distribution, Steam Traps, Condensate and Flash-steam utilization, Energy conservation opportunities

Text Books

- Energy Manager Training Manual (4 Volumes) available at a website administered by Bureau of Energy Efficiency (BEE), a statutory body under Ministry of Power, Government of India.
- S Rao and B BParulekar ," Energy Technology" Khanna Publishers, 2012
- K. V. Sharma, P. Venkataseshaiah, "Energy Management and Conservation", I.K. International Publishing House Pvt. Limited, 2011

Reference Books

- Witte. L.C., P.S. Schmidt, D.R. Brown, "Industrial Energy Management and Utilization" Hemisphere Publication, Washington, 1988
- D.A. Reay, "Industrial Energy conservation: A handbook for engineers and managers", Pergamon Press, 1979
- Patrick Steven R., Patric Dale R. and Fordo Stephen : Energy conservation Guide book, The Fairmont Press Inc.7, 1993

- Albert Thumann, “Plant Engineers and managers Guide to Energy conservation”, The Fairmont Press, 2010
- WR Murphy and G McKay, “Energy Management”, Butterworth Heinemann, Elsevier, 1982
- Frank Kreith & D. Yogi Goswami, “Energy management and conservation handbook”, CRC Press, Tailor and Francis Group, 2008

Departmental Elective- III

ME (DE) XX001 Heating Ventilation Air Conditioning and Refrigeration

Teaching Scheme	**Examination Scheme**
Lectures : 3hrs / week	Internal Test 1: 20 marks
	Internal Test 2: 20 marks
	End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- Determine the performance parameters of trans-critical & ejector refrigeration systems
- Estimate thermal performance of compressor, evaporator, condenser and cooling tower.
- Describe refrigerant piping design, capacity & safety controls and balancing of vapour compressor system.
- Explain importance of indoor and outdoor design conditions, IAQ, ventilation and air distribution system.
- Estimate heat transmission through building walls using CLTD and decrement factor &time lag methods with energy-efficient and cost-effective measures for building envelope.
- Explain working of types of desiccant, evaporative, thermal storage, radiant cooling, clean room and heat pump air-conditioning systems

Unit 1 **(5hrs)**

Advanced Vapour Compression Cycles:

Review of vapour compression cycle, Trans-critical cycle and their types, Ejector refrigeration cycle and their types. Presentation of cycle on P-h and T-s chart.Analysis of cycles.

Unit 2 **(8hrs)**

Thermal Design of Refrigeration System Components:

Characteristic curves of reciprocating & Centrifugal compressors, sizing of reciprocating compressor, Performance analysis of Dx evaporator, air-cooled condenser, and shell & tube condenser. Operating Characteristics of expansion device, Liquid Charge in the Sensing Bulb, Hunting of Thermostatic Expansion Valve. Cooling Tower: Types & analysis of cooling towers, cooling tower thermal performance, tower efficiency

Unit 3 **(5hrs)**

Practical Aspects of Vapour Compression System:

Refrigerant Piping : Copper Tubing, Piping Design for Reciprocating Refrigeration Systems, Size of Copper Tube, Refrigeration Load, and Pressure Drop, Sizing Procedure, Suction Line, Discharge Line (Hot-Gas Line), Liquid Line

Safety Controls: Low-Pressure and High-Pressure Controls. Low-Temperature Control, Frost Control, Oil Pressure Failure Control. Motor Overload Control.

Vapour compression system balance: Performance characteristics of the condensing unit & Compressor-capillary tube.

Unit 4 **(8hrs)**

Ventilation and Infiltration:

Basic parameters, factors affecting thermal comforts, Comfort-Discomfort Diagrams, Indoor Temperature, Relative Humidity, and Air Velocity,

Indoor Air Quality: Indoor Air Contaminants, Basic Strategies to Improve Indoor Air Quality, Fresh Air Requirements for Occupants, The use of outdoor weather data in Design, Outdoor Weather Characteristics and Their Influence

Ventilation for cooling: Natural ventilation, mechanical ventilation

Space air distribution: Design of air distribution systems, Types of air distribution devices, Airflow patterns inside conditioned space, stratified mixing flow, Cold air distribution, Displacement flow: Selection of supply air outlets.

Unit 5 **(8hrs)**

Heat Load Estimation in Building Structures:

Solar radiation, Heat gain through fenestrations, Space load characteristics, cooling load and coil load calculations, Overall heat transmission coefficient, air spaces, sol-air temperature, Decrement factor & time lag method, Equivalent Temperature Differential (ETD), Total heat balance. Energy-efficient and cost-effective measures for building envelope, Concept of ECBC, Computerized cooling load calculations, Simulation of psychrometric processes, Simulation of air flow in AC systems.

Unit 6 **(6hrs)**

Advanced Air-conditioning Systems:

Desiccant-Based Air Conditioning Systems : Introduction, Sorbents & Desiccants, Dehumidification, Liquid Spray Tower, Solid Packed Tower, Rotary Desiccant Dehumidifiers, Hybrid Cycles, Solid Desiccant Air-Conditioning, Solar Vapour Compression Refrigeration System Radiant cooling, Performance Metrics Testing Standards (Theoretical treatment).

Text Books

- Arora R.C., Refrigeration and Air Conditioning, PHI, India
- Dossat Ray J., Principal of Refrigeration, Pearson, India
- Arora C P, Refrigeration and Air Conditioning, Tata McGraw Hill
- Manohar Prasad, Refrigeration and Air-conditioning, Wiley Eastern Limited, 1983
- S.N. Sapali "Refrigeration and Air-conditioning", PHI (Second Edition) 2016

Reference Books

- Threlkeld J.L., Thermal Environmental Engineering, Prentice Hall Inc. New Delhi
- ASHRAE Handbook (HVAC Equipments)
- Stocker W.F. and Jones J.W., Refrigeration and Air-conditioning, McGraw Hill International editions 1982.
- Roger Legg, Air conditioning systems: Design, Commissioning and maintenance
- Shan Wang, Handbook of Refrigeration and Air Conditioning, McGrawHill Publications
- Wilbert Stocker, Industrial Refrigeration, McGrawHill Publications
- Keith Harold, Absorption chillers and Heat Pumps, McGrawHill publications
- ASHRAE, Air Conditioning System Design Manual, IInd edition, ASHRAE.

Departmental Elective- III
ME (DE) XX001 Connected and Autonomous Vehicle

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- To know about smart vehicles of today transport
- To understand inter and intra communication for automotive engineering
- To understand vehicular data application and standards
- To understand various levels of Autonomous Driving as per SAE Classification
- To understand the autonomous vehicles & its subsystems.

UNIT 1

Smart Vehicle in Today Transport:
Sensors applications to traffic management, street types and functions, traffic management canters, Inter-vehicle communications: Cooperate driving: Accident driving, frontal collision, prevention, hazards warning, road departure and speed alert, consumer assistance, Traffic information, mobile & multimedia services, smart parking, evolving smart vehicle, microprocessors and algorithm for smart vehicles.

UNIT 2

Basic of Vehicular Communication:

Fundamental concepts, Frequency, bandwidth, power measurement, signal-to-noise ratio, transmission rate constraints, radio-frequency spectrum allocation, RADAR: operation and types, forward radar, side radar, Wireless networking: transmitter and receiver, GPS, cellular transmission, Data recorder, IEEE Wireless LANs & IEEE standards.

UNIT 3

Intra-Vehicle & Inter-Vehicle Communication:

Intra-vehicle communication: Wired communications, Network comparison, LIN, CAN, FlexRay, MOST & applications of different communication protocols, Wireless Communications: Bluetooth, evolution, classes, operation, spectrum utilization, operational modes, and vehicle applications. Inter-vehicle communication: Adhoc Networking, communication technologies, vehicle frequency utilization for different devices, Infrastructure-to-vehicle communication, vehicle-to-vehicle communication.

UNIT 4

Vehicular data application & mobility control:

Security threats, privacy threats, basic data security capabilities, cryptographic mechanism: Introduction, categories of cryptography mechanism, Dedicated Short Range Communication for Vehicles, Intelligent Transportation System: requirement for public, transport vehicle operation in India, Standards: AIS 140, IEEE 1609, CVRIA.

UNIT 5

Autonomous Vehicles:

Overview of autonomous vehicles, performance requirement, Levels of Autonomous driving-SAE J3016, Autonomous Driving in political, social and historical contexts, research related to autonomous vehicles, national & international legislations, Evolution of ADAS (Advanced Driver Assistance System),Operational Design Domain (ODD), Object and Event Detection and Response (OEDR),Location & Mapping System, Sensor Fusion, sensor integration architecture, multiple sensor fusion, Decision Making in Autonomous systems, Autonomous vehicles control systems.

Text Books:

1. Luca Delgrossi, Tao Zhang, “Vehicle Safety Comminications- Protocols, Security, and Privacy”, John Wiley & Sons, Inc., 2012.
2. Syed FarazHasan, NazmulSiddique and ShyamChakraborty, “Intelligent Transportation Systems-802.11-based Vehicular Communications” Springer International Publishing AG, 2018.
3. Gilbert Held, “Inter- and Intra-Vehicle Communications”, Auerbach Publications, 2008.
4. Hong Cheng, “Autonomous Intelligent Vehicles Theory, Algorithms, and Implementation”, Springer London Dordrecht Heidelberg New York, 2011.

5. Markus Maurer, J. Christian Gerdes, Barbara Lenz, Hermann Winner, “Autonomous Driving Technical, Legal and Social Aspects”, Springer-Verlag GmbH Berlin Heidelberg, 2015.

Reference Books:

1. Fei Hu, “Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications”, CRC Press, Taylor & Francis Group, 2018.
2. Lawrence A. Klein, “ITS Sensors and Architectures for Traffic Management and Connected Vehicles”, CRC Press, Taylor & Francis Group, 2018.
3. NicuBizon, Lucian Dascalescu and NaserMahdaviTabatabaei, “Autonomous Vehicles-Intelligent Transport Systems and Smart Technologies”, Nova Science Publishers, 2014.
4. Ronald K. Jurgen, “Autonomous Vehicles for Safer Driving”, SAE International, 2012.

Departmental Elective- III
ME (DE) XX001 Computational Convective Heat Transfer

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Anticipate and describe the consequence of convective heat transfer in thermal analysis of engineering systems.
- Formulate, and evaluate convective heat transfer solution for laminar internal, and external flow.
- Formulate, evaluate and develop convective heat transfer solution for natural Convection heat transfer from various geometries.
- Formulate, evaluate and develop convective heat transfer solution for turbulent convection.
- Model Convective heat transfer for internal flow and external flow under different conditions using commecercial software.

Unit 1 **(5 hrs)**

Governing equations:
Different Convective Modes, governing Equations: Continuity, momentum and energy Equations, thermal boundary layer, boundary layer approximations to momentum and energy, forced convection: low Prandtl number over a flat plate.

Unit 2 **(7 hrs)**

Laminar external flow and heat transfer:
Similarity solutions for flat plate - blasius solution, flows with pressure gradient - Falkner-Skan and Eckert solutions, and flow with transpiration
Integral method solutions for flow over an isothermal flat plate, flat plate with constant heat flux and with varying surface temperature - Duhamel's method, flows with pressure gradient - Von karman-Pohlhausen method.

Unit 3 **(6 hrs)**

Laminar internal flow and heat transfer:
(a) Exact solutions to n-s equations for flow through channels and circular pipe, fully developed forced convection in pipes with different wall boundary conditions, forced convection in the thermal entrance region of ducts and channels (Graetz solution), heat transfer in the combined entrance region, (b) Integral method for internal flows with different wall boundary conditions.

Unit 4 **(6 hrs)**

Natural convection heat transfer:
Governing equations for natural convection, Boussinesq approximation, Dimensional Analysis, Similarity solutions for Laminar flow past a vertical plate with constant wall temperature and heat flux conditions, Integral method for natural convection flow past vertical plate, effects of inclination, Natural convection in enclosures, mixed convection heat transfer past vertical plate and in enclosures.

Unit 5 **(7 hrs)**

Turbulent convection:
Governing equations for averaged turbulent flow field (RANS),analogies between heat and mass transfer (Reynolds, Prandtl-Taylor and von Karman Analogies), turbulence models (Zero, one and two equation models), turbulent flow and heat transfer across flat plate and circular tube, turbulent natural convection heat transfer, empirical correlations for different configurations.

Unit 6 **(5 hrs)**

Modelling of Convective heat transfer
Tutorials on modelling convective heat transfer process for internal flow through circular tubes under constant wall temperature, constant heat flux conditions. Modelling of natural convection from heated surfaces, flat plates, spheres etc. at different orientations.

Textbooks:

* Convective Heat and Mass Transfer, 4th Edition by W. Kays, M. Crawford and B. Weigand, McGraw Hill International, 2005.
* Convective Heat Transfer, 2nd Edition by S.Kakac and Y. Yener, CRC Press, 1995.
* Convection Heat Transfer, 3rd Edition by A.Bejan, John Wiley, 2004
* H. K. Versteeg and W. Malalasekera, "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Longman Scientific & Technical, 1995.

1.

References:

* Fundamentals of Heat and Mass Transfer, 7th Edition by F.P. Incropera and D. Dewitt, John Wiley, 2011.
* Boundary Layer Theory, 8th Edition by H.Schlichting and K. Gersten, Springer-Verlag, 2000.

Departmental Elective- III
ME (DE) XX001 Mechanics of Composite Materials

Teaching Scheme	**Examination Scheme**
Lectures : 3hrs / week	Internal Test 1: 20 marks
	Internal Test 2: 20 marks
	End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

* Differentiate the basic concepts and difference between composite materials with conventional materials.
* Determine role of constituent materials in defining the average properties and response of composite materials on macroscopic level.
* Knowledge for finding failure envelopes and stress-strain plots of laminates.
* Utilize subject knowledge using computer programs to solve problems at structural level.

Overview:

In pursuit of increasing the efficiency of structures use of composite materials is increased. To understand the role of composite materials for replacement of conventional materials, knowing mechanics of composite materials is essential. After understanding this subject you will be able to start stress and strength analysis of any composite structures using FEA (Finite Element Method) based software. Pre-requisite for this course is basics of Solid Mechanics.

Unit 1. Introduction **[03 hrs]**

Definition and characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus

Unit 2. Basic Concepts and Characteristics **[04 hrs]**

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Macromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials

Unit 3. Elastic Behavior of Unidirectional Lamina [05 hrs]

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters

Unit 4. Strength of Unidirectional Lamina [05 hrs]

Micromechanics of failure; failure mechanisms, Macromechanical strength parameters, Macromechanical failure theories, Applicability of various failure theories

Unit 5. Elastic Behaviorof Laminate [08 hrs]

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates

Hygrothermal Effects:Hygrothermal effects on mechanical behavior, Hygrothermal stress-strain relations, Hygro-thermoelastic stress analysis of laminates, Residual stresses, Warpage

Unit 6. Stress and Failure Analysis of Laminates [05 hrs]

Types of failures, Stress analysis and safety factors for first ply failure of symmetric laminates, Micromechanics of progressive failure; Progressive and ultimate laminate failure, Design methodology for structural composite materials

Reference Books:

1. Isaac M. Daniels, OriIshai, “Engineering Mechaincs of Composite Materials”, Oxford University Press, 1994.
2. Bhagwan D. Agarwal, Lawrence J. Broutman, “Analysis and Performance of fiber composites”, John Wiley and Sons, Inc. 1990.
3. Mathews, F. L. and Rawlings, R. D., “Composite Materials: Engineering and Science”, CRC Press, Boca Raton, 2003.
4. MadhujitMukhopadhyay, “Mechanics of Composite Materials and Structures”, University Press, 2004.
5. Mazumdar S. K., “Composaite Manufacturing – Materials, Product and Processing Engineering”, CRC Press, Boca Raton, 2002.
6. Robert M. Jones, “Mechanics of Composite Materials”, Taylor and Francis, Inc., 1999.

Departmental Elective- III
ME (DE) XX001 Condition Monitoring

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks

End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- Understand the concept of condition-based maintenance of plant, machinery, equipment and structures, etc., in online and offline mode
- Understand the types of signals and sensors used to acquire vital health parameters of machineries to monitor changes that precede equipment failures.
- Analyze the fault in the machinery like gear boxes, bearings and shafts by using a variety of monitoring techniques.
- Interpret the data of rotating machinery and detect the onset of impending faults through vibration signature, acoustic emissions, thermography, oil-debris analysis, motor current signature analysis and /or several other NDT methods (Eddy Current Testing, Ultrasonic Testing, Radiography, etc.).
- Understand the techniques and analyze electronic component heat generation, leak detection as an aid to condition monitoring.
- Understand the techniques for the condition monitoring of the buildings, structures etc

Unit1: Introduction to Condition Monitoring and Principles of Maintenance [5 Hrs]

Machinery Condition Monitoring, Fault Diagnosis and Prognosis, Overview of Different Techniques of Condition Monitoring, Principles of Maintenance, Reactive, Preventive, Predictive Maintenance, Bath Tub Curve, Brief concept of Failure Modes Effects and Criticality Analysis (FMECA), RAMS standards (Reliability, Availability, Maintainability and Safety)

Unit 2: Digital Signal Processing and Instrumentation [6Hrs]

Introduction, Classification of Digital Signal Processing, Fundamentals of Fast Fourier Transform, Computer-Aided Data Acquisition, Signal Conditioning, Engine Vibration, Static and Dynamic Measurements, Frequency Response, Dynamic Range, Basic Measuring Equipment, Signal Amplifiers, RMS/Peak Meters, Oscilloscope, Signal Filter, etc., Laser-Based Measurements, Current Measurements, Chemical Composition Measurement, Data Recorders, etc.

Unit 3: Machinery Vibrations and Vibration Based CBM [10Hrs]

Introduction to Vibration, Forced Vibration Response, Characteristics of Vibrating Systems, Vibration of Continuous Systems, Experimental Modal Analysis, Mode Shapes and Operational Deflection Shapes, Rotodynamics, Unbalance Response and Critical Speed, Journal Bearings, Condition Monitoring in Large Rotor Systems

Misalignment Detection, Eccentricity Detection, Cracked Shaft, Bowed and Bent Shaft, Rub, Looseness, Bearing Defects, Gear Faults, etc, and case studies thereof.

Unit4: Noise Monitoring and Electrical Machinery Faults [7Hrs]

Introduction to Acoustical terminologies, Sound Pressure Level, A-Weighting, Sound Power Level, Sound Intensity Level, Octave Frequency Bands, Sound Fields, Near-Field Condition, Far-Field Condition, Anechoic/Reverberation Chamber, Noise Measurements, Acoustic Emission.
Faults and fault detection in Electric Motors, Fault Detection in Electro-Mechanical Systems by MCSA, Relation between Vibration and Motor Current, Fault Detection in a Submersible Pumps, etc.

Unit 5: Thermography and Wear Debris Analysis [7 Hrs]

Introduction to Thermography, Thermal Imaging Devices: Optical Pyrometer, Infrared Cameras, Industrial Applications of Thermography in Condition Monitoring
Electrical and Electronic Component Heat Generation, Leakage Detection,
Introduction to Wear Debris Analysis, Mechanisms of Wear, Detection of Wear Particles, Common Wear Materials, Oil Sampling Technique, Oil Analysis, Limits of Oil Analysis,
Other Methods: Eddy Current Testing, Ultrasonic Testing, Radiography, etc.

Unit 6: Cutting Tool Condition Monito [6Hrs]

Introduction, Tool Wear, Sensor Fusion in TCM, Sensors for Tool Condition Monitoring, Direct Tool Wear Measurements: Dimensional Deviation, Tool-Work Electric Resistance, Optical Sensors, Force/ Torque Sensor, Vibration Sensor, Surface Roughness, Acoustic Emission Sensor, Use of IoT, ML, AI and Data analytics in condition monitoring and fault diagnosis, etc.

Text books:

- Mohanty R A, Machinery, Condition Monitoring Principles and Practices, CRC Press, Taylor and Francis Group, (2015).
- P Girdhar, Machinery vibration analysis and predictive maintenance, Elsevier Newnes Publications. (2004)
- Collacott R.A., Mechanical fault diagnosis and condition monitoring, London: Chapman and Hall (1977).
- Rao, B. K. N., Handbook of condition monitoring, Elsevier advanced technology, Oxford. (1996)
- A Davis – Handbook of condition monitoring, London: Chapman and Hall. (1998)

Reference books:

- R G Eisenmann et-al – Machinery malfunction diagnosis and correction, Hewlett-Packard professional books. (1997)
- Robert Bond Randall, Vibration-based Condition Monitoring: Industrial, Aerospace and Automotive Applications (Google eBook) John Wiley & Sons. (2011)
- Ron Barron, Engineering condition monitoring: practice, methods and applications, Longman, (1996)
- E. D. Yardley, Condition Monitoring: Engineering the Practice, Wiley. (2002)

Departmental Elective- III

ME (DE) XX001 AI and ML for Mechanical Engineers

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Demonstrate fundamentals of AI&ML, apply feature extraction and selection techniques
- Apply machine learning algorithms for classification and regression problems
- Devise and develop a machine learning model using various steps
- Explain concepts of reinforced and deep learning
- Simulate machine learning model in mechanical engineering problems

Unit 1: Introduction
[07 Hrs.]
History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Machine Learning Basics: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Approaches to AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Approaches to ML: Supervised learning, Unsupervised learning, Reinforcement learning

Unit 2: Development of ML Model **[08 Hrs.]**
Problem identification: Classification, Clustering, Regression, Ranking. Steps in ML modelling: Data Collection, Data pre-processing, Model Selection, Feature Extraction, Feature Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions

Unit 4: Feature Extraction and Selection **[07 Hrs.]**
Feature extraction: Statistical features, Principal Component Analysis. Feature selection: Ranking, Decision tree - Entropy reduction & information gain, Exhaustive, best first, Greedy forward & backward

Unit 5: Classification & Regression **[08 Hrs.]**
Classification: Decision tree, Random forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbour (KNN)

Unit 7: Deep & Reinforced Learning **[07 Hrs.]**
Introduction to Deep learning: Artificial neural networks, Deep neural networks, Convolutional neural network, Recurrent neural network, Long short term memory LSTM, Auto encoder (AE), Dip belief network, Generative adversarial network, Extreme learning machine, Deep residual network. Introduction to reinforced learning: Motivation, background, characteristics,

Algorithms for control learning: Criterion of optimality, Brute force, Value function, direct policy search, Model-based algorithms, Associative reinforcement learning, Deep reinforcement learning, Inverse reinforcement learning, Safe Reinforcement Learning, Partially Supervised Reinforcement Learning (PSRL)

Unit 8: Advanced & Recent Techniques [08 Hrs.]
Pitfalls of traditional ML models, Data expansion and augmentation, Adversarial Machine learning (AML), Domain generalization and adaptation, Transfer Learning (TL), Explainable AI (XAI), Digital Twin (DT), Multi-models, Multi-agent adaptation, Self-paced learning

Applications & Case Studies
- Health monitoring of rotating machine component (such as cutting tool, gearbox, hydraulic brake, pumps, turbines to name a few)
- Image-based classification of machine elements such as nuts, bolts, washers etc.
- Predicting the output and efficiency of thermal systems
- Predicting the material property & new materials discovery
- Wear state estimation of rolling element bearings using SVM
- Battery performance evaluation and management for a case of electric mobility
- Prediction of refrigerant two-phase pressure drop inside heat exchangers
- Predictive modeling of engine emissions
- Image driven machine learning methods for microstructure recognition
- Flow optimization using machine learning
- Intelligent ERP, ML-Driven Supply Chain
- Reinforcement learning for tool life extension on multi-sensor condition monitoring
- Sample augmentation for intelligent milling tool wear condition monitoring using numerical simulation and generative adversarial network
- An Explainable AI-Based fault diagnosis model for bearings
- Domain generalization & transfer learning in rotating machinery fault diagnostics DNN
- Big data oriented smart tool condition monitoring system
- Flow control via Reinforcement learning
- Kinematic Synthesis using Reinforcement Learning

Text Books:

- Tom M. Mitchell, “Machine Learning”, McGraw-Hill, 1997
- ShaiShalev-Shwartz and Shai Ben-David, “Understanding Machine Learning”, Cambridge University Press, 2017.
- MehryarMohri, AfshinRostamizadeh and AmeetTalwalkar, “Foundations of Machine Learning”, MIT Press, 2012
- P. Flach, “Machine Learning: The Art and Science of Algorithms that Make Sense of Data. First Edition”, Cambridge University Press, 2012.
- Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.

Papers:

- P. Domingos, “A Few Useful Things to Know about Machine Learning”, Communications of the ACM, vol. 55, no. 10, pp. 78 - 87, 2012.
- Steven L. Brunton, Bernd R. Noack, and PetrosKoumoutsakos, “Machine Learning for Fluid Mechanics”, Annual Review of Fluid Mechanics, vol. 52, pp. 477–508, 2020.

Departmental Elective- III
ME (DE) XX001 Sensors and Actuators in Robotics Technology

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:
- Analyze sensory systems in robotics.
- Select the sensor for robotic application and design the system.
- Analyze actuators and configuring the parameters of Actuators

Syllabus Contents
Anatomy of Robotic system,
Basics of Sensors used in the Robotics Technology. Types of sensors: Pressure/contact. Resistive position. Infrared. Light. Position Sensors, optical encoders, proximity sensors, Range sensors Ultrasonic sensors, Touch and Slip sensors. sensors for motion and position, Force, torque and tactile sensors, Flow sensors, Temperature sensing devices,
Vision Sensors :- Vision System Devices, Image acquisition, Masking, Sampling and quantization, Image Processing Techniques , Noise reduction methods, Edge detection, Segmentation.
Advanced Sensor Technology - Smart sensors, MEMS based sensors, Innovations in sensor technology

Actuators and its selection while designing a robot system. Types of transmission systems, Electric Actuators - Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotatory actuators, Piezo electric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper motors Servomotors.

Pneumatic & Hydraulic actuators - Hydraulic and pneumatic power actuation devices Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators, design considerations and selection, pneumatic cylinders , pneumatic drive system, Linear & rotary actuators.
Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy-based actuators, underactuated robotic hand

Reference Books:

- Mc Comb, G. Robot builder's bonanza. 5th ed. New York: McGraw-Hill, 2019. ISBN 9781260135015.
- Braünl, T. Embedded robotics: mobile robot design and applications with embedded systems. 3rd ed. Berlin ; Heidelberg: Springer, 2008. ISBN 9783540705338.

- Martin, F.G. Robotic explorations: a hands-on introduction to engineering. Upper Saddle River, N.J.: Prentice-Hall, 2001. ISBN 0130895687.
- D. Patranabis, Sensors and Transducers, PHI, 2nd Ed 2013
- Jon S. Wilson, Sensor Technology Handbook, Elsevier, 2005
- Andrzej M. Pawlak, Sensors and Actuators in mechatronics, Taylor & Francis Group, 2007
- S. R. Ruocco, Robot Sensors & Transducers, Springer, 2013
- Gerard C., M. Meijer, Smart Sensors System, Wiley, 2008

Departmental Elective- III
ME (DE) XX001 Project Management

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:
- Manage the scope, cost, timing, and quality of the project, at all times focused on project success as defined by project stakeholders.
- Align the project to the organization's strategic plans and business justification throughout its lifecycle.
- Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements in consultation with stakeholders.
- Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success.
- Utilize technology tools for communication, collaboration, information management, and decision support.
- Implement general business concepts, practices, and tools to facilitate project success.
- Apply appropriate legal and ethical standards

Unit I: Project Integration & Structures
Project and Importance of Project Management, Project Life Cycle, Role and Responsibilities of Project Manager, Project Integration Management. Project Management Structures, Right Project Management Structure, Organization Culture [6 hrs]

Unit II: Project Appraisal & Selection
Organization Strategy: Strategic Management Process, Need for Portfolio Management, Selection Criteria: Financial and Non-Financial [6 hrs]

Unit III: Project Planning, scheduling & Control
Defining the Project: Project Scope, Creating Work Breakdown Structure, Responsibility Matrix and Communication Plan.
Quality of Estimates and Guidelines, Methods for Estimating Project Times and Cost, Types of cost [6Hrs]

Unit IV: Managing Risk & People

Risk Management Process, Contingency Plans, Change Control Management, Managing Vs. Leading A Project Risk Management Process, Contingency Plans, Change Control Management, Managing Vs. Leading A Project

Managing Project Stakeholders, Influence as Exchange, Managing Project Teams: Team Development, Establishing Team identity, Managing Conflicts, Project Team Pitfalls [6 hrs]

Unit V: Project Planning, Scheduling & Control problems CPM & PERT

Developing a project plan and project network, AOA and AON diagram, CPM calculations, problem solving, PERT model, pert calculations, time scale network, problem solving , network scheduling with limited resources, heuristic programs, resource allocation & spar model, problem solving, precedence diagramming, decision networks, Pert network, problem solving, reducing project duration, project cost – duration graph, crashing of activities, project monitoring information system, developing status report, earned value analysis. [6 hrs]

Unit VI: Project Audit, Closure

Project audit, project closure, retrospectives [6 hrs]

Text Books:

- Cliford F. Grey, Erik W. Larson, Gautam V. Desai "Project Management The Managerial Process", McGraw Hill Education(India) Private Limited, New Delhi, Sixth Edition, 2014
- Jerome D Wiest& Ferdinand K Levy, "A Management Guide to PERT/ CPM with GERT/PDM/DCPM and other Networks", PHI Learning Private Limited, 2nd Edition 2009

Reference Books:

- Kerzner Harold," Project Management: A Systems Approach to Planning, Scheduling and Controlling", Wiley Student Edition 10th Ed.

Departmental Elective- IV
ME (DE) XX001 Design of Heat Exchangers

Teaching Scheme
Lectures : 3hrs / week
Tutorial: 1 hr/week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- Understand and explain different types of heat exchangers and its performance
- Design and analyze various heat exchangers using heat exchanger design standards and codes
- Appreciate and analyze the consequences of fouling on performance of heat exchangers and determine fouling resistance

- Carry out Thermal and Hydraulic design and analysis of heat exchangers for various real time problems including heat transfer coefficient enhancement and fouling effect
- Use simulation and optimization tools in heat exchanger design

Unit 1 **(6 hrs)**

Introduction to Heat Exchangers:
Types of heat exchangers and their applications, Flow arrangements and temperature distributions in transfer type of heat exchangers, Overall heat transfer coefficient;- Clean overall heat transfer coefficient, dirt factor dirt overall heat transfer coefficient, dirt factors for various process services. Basic design equation, Mean temperature difference Concept; LMTD for different flow arrangement, correction factor for LMTD for cross flow and multi –pass heat exchangers, Mean temperature difference method.

Unit 2 **(6 hrs)**

Shell and Tube Heat Exchangers:
Constructional features; Applications; Effectiveness-NTU method for heat exchanger design/ analysis, ϵ-NTU method, P-NTU method, Rating and sizing problem; Correlations for tube side pressure drop and heat transfer coefficients, Pressure drop; Kern's, and Bell Delaware's method, heat transfer coefficient correlations for shell side flow.

Unit 3 **(6 hrs)**

Fouling of heat exchanger**,** effects of fouling, categories of fouling, fundamental processes of fouling, determination of fouling resistance and consequences of fouling on performance of heat exchangers
By – Pass and Leakage Calculation Procedure for Shell and Tube Heat Exchanger

Unit 4 **(6 hrs)**

Double Pipe Heat Exchangers:
Thermal and Hydraulic design of inner tube, Thermal and hydraulic analysis of Annulus, Pressure drop analysis
Compact Heat Exchangers: Thermal and Hydraulic design of compact heat exchanger

Unit 5 **(6 hrs)**

Air-Cooled Heat Exchangers:
Air as coolant for industrial processes; custom-built units; fin-tube systems for air coolers; fin-tube bundles; thermal rating; tube side flow arrangements; cooling air supply by fans; cooling air supply in natural draft towers.

Unit 6 **(6 hrs)**

Mechanical Design of Heat Exchangers:
Design standards and codes, key terms in heat exchanger design, and thickness calculation for major components such as tube sheet, shell, tubes etc.

Text Books

- Ramesh K. Shah and Dusan P. Sekulic, “Fundamentals of Heat Exchanger Design” John Wiley & sons Inc., 2013

Reference Books

- D.C. Kern, “Process Heat Transfer”, McGraw Hill, 1950
- SadikKakac and Hongton Liu, “Heat Exchangers: Selection, Rating and Thermal Design” CRC Press, 1998
- Geofrey F. Hewitt, “Hand Book of Heat Exchanger Design”,Begell House, 1992.
- “T.E.M.A. Standard”, New York, 1999
- KuppanThulukkanam, “Heat Exchanger Design Handbook”, CRC Press, 2nd Edition, 2013

Departmental Elective- IV
ME (DE) XX001 Introduction to Nuclear Engineering

Teaching Scheme
Lectures : 2hrs / week
Tutorial: 1 hr/week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- The basic concepts and processes taking place inside a nuclear reactor, such as nuclear fission, neutron production, scattering, diffusion, slowing down and absorption.
- The student will be familiar with concepts of reactor criticality, the relationship between the dimension and fissile material concentration in a critical geometry.
- Time dependent (transient) behaviour of power reactor in non-steady state operation and the means to control the reactor.
- It will familiarize the student with concepts of heat removal from reactor core, reactor safety and radiation protection.
- Enhance problem solving skills, particularly solving differential equations in simple geometries.

Unit 1: (6hrs)

Basics of nuclear fission and power from fission

Radioactivity, nuclear reactions, cross sections, nuclear fission, power from fission, conversion and breeding

Unit 2: (9hrs)

Neutron transport and diffusion

Neutron transport equation, diffusion theory approximation, Fick’s law, solutions to diffusion equation for point source, planar source, etc., energy loss in elastic collisions, neutron slowing down

Unit 3: **(9hrs)**
Multi-group, multi-region diffusion equation, concept of criticality

Solution of multi-group diffusion equations in one region and multi-region reactors, concept of criticality of thermal reactors

Unit 4: **(6hrs)**
Reactor kinetics and control

Derivation of point kinetics equations, inhour equation, solutions for simple cases of reactivity additions, fission product poison, reactivity coefficients

Unit 5: **(3hrs)**

Heat removal from reactor core

Solution of heat transfer equation in reactor core, temperature distribution, critical heat flux, etc.

Unit 6: **(3hrs)**
Reactor safety, radiation protection

Reactor safety philosophy, defence in depth, units of radioactivity exposure, radiation protection standards

Text Books

- Introduction to Nuclear Engineering (3rd Edition) by John R. Lamarsh, Anthony J. Barrata, Prentice Hall, (2001).
- Nuclear Reactor Analysis, by James J. Duderstadt and Lewis J. Hamilton, John Wiley (1976)

Reference Books

- Nuclear Reactor Engineering vol.1, Reactor Design Basics, CBS Publishers (2019).
- Introduction to Nuclear Reactor Theory, by John R. Lamarsh, Addison-Wesley, (1966).

Departmental Elective- IV
ME (DE) XX001 Nano Technology in Solar Engineering

Teaching Scheme	**Examination Scheme**
Lectures : 3hrs / week	Internal Test 1: 20 marks
	Internal Test 2: 20 marks
	End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Describes the fundamentals of nanoparticles for the harnessing of solar energy

- Characterization techniques used for nano size particles
- Performance characterization of volumetric absorption-based solar collector
- Apply the concepts of nanotechnology on various applications

Unit 1: Fundamentals of solar energy [4]
Basic definitions related to solar energy, electromagnetic waves, solar angles, solar earth geometry, working mechanism of surface absorption-based solar collector (non-concentrating and concentrating), issues related to surface-absorption based solar collectors.

Unit 2: Fundamental of nanoparticles [8]
Concept of nanoparticles and nanofluid, materials of nanoparticles (metallic, core/shell, graphite and non-metallic), preparation methods of nanofluids (one step and two step methods), importance of nanosize, general issues of concern with nanoparticles, dispersion of nanoparticles in liquids.

Unit 3: Characterization of nanoparticles [8]
Transmission electron microscopy, X-ray diffraction, Infrared, Raman and other spectroscopies, zeta potential, UV-Vis spectroscopy, effect of shape of nanoparticles on the optical properties, forces exerted on nanoparticles.

Unit 4: Radiative properties [10]
Radiative transfer equation, derivation of the transfer equation, absorbing, emitting and non-scattering medium, scattering medium, out-scattering, in-scattering, phase function, radiative heat flux, single scattering albedo, Mie scattering, Rayleigh scattering, absorption coefficient and efficiency.

Unit 5: Dispersion theory in nanoparticles [6]
Interaction of electromagnetic radiation with matter, Lorentz model, Drude model, Interaction of electromagnetic radiation with nanofluid

Unit 6: Nanofluid based solar collector [7]
Working mechanism of nanofluid based solar collector, factors affecting the performance of solar collector, effect of mass flow rate, effect of volume fraction, effect of depth of nanofluid, effect of irradiation, applications of nanofluid based solar collectors.

Text books:

- Brewster, M. Q. Thermal Radiative Transfer and Properties. (Wiley, 1992).
- Das, S. K., Choi, S. U. S., Yu, W. & Pradeep, T. Nanofluids: Science and Technology. Wiley. Wiley (2007).
- Duffie, J. A. & Beckman, W. A. Solar Engineering of Thermal Processes. 4th ed. John Wiley & Sons. John Wiley & Sons (2013).
- Modest, M. F. Radiative Heat Transfer. Academic Process vol. 5 3896–3915 (2003).

Departmental Elective- IV
ME (DE) Fracture Mechanics

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Predict diferent modes of failure and diferentiate between brittle fracture and ductile fracture.
- Interpret the damage tolerance of a component with a crack by analyzing the problem by methods of energy release rate and stress intensity factor.
- Explore the test methods for determining critical energy release rate, critical stress intensity factor.
- Analyze stress and displacement fields at the tip of edge crack and embedded crack.
- Analyze variable amplitude fatigue in a component when a crack is present in it.
- Estimate crack propagation, and environment assisted cracking along with various crack detection techniques.

Unit I:

Energy Release Rate:
Kinds of failure, Brittle and ductile fracture, Modes of fracture failure, Damage tolerance, Grifth's Dilemma, Surface energy, Grifth's realization, Grifth's Analysis, Energy release rate, crack resistance, stable and unstable crack growth, R-curve for Brittle Cracks, Critical Energy Release Rate. [6 hrs]

Unit II:

Stress Intensity Factor:
Introduction, Stress and Displacement Fields in Isotropic Elastic Materials ,Stress intensity factor, Background for Mathematical Analysis, Westergaard's Approach, Application of the Principle of Superposition , Crack in a Plate of Finite Dimensions, edge cracks, embedded cracks , The Relation between GI and KI , critical stress intensity factor, Bending and Twisting of Cracked Plates. [6 hrs]

Unit III:

Crack tip plasticity:
Shape and size of plastic zone, efective crack length, efect of plate thickness, Crack tip opening displacement, Definition of the J-Integral, Path Independence, Stress-Strain Relation, Relationship between CTOD, KI and GI for Small Scale Yielding, Equivalence between CTOD and J. [6 hrs]

Unit IV :

Test Methods:

Introduction, Test methods for determining critical energy release rate, Test Methods to Determine JIc, Test Methods to Determine GIC and GIIC, Determination of Critical CTOD. [6 hrs]

Unit V:

Fatigue Failure and Environment-assisted fracture:
Introduction, Terminology, S-N Curve, Crack Initiation, Fatigue failure: Crack propagation, efect of an overload, crack closure, variable amplitude fatigue load, Micro mechanisms, Environment-assisted fracture, Environmentassisted Fatigue Failure, Major Factors Infuencing Environment-assisted Fracture, Test Methods. [6 hrs]

Unit VI:

Crack detection techniques:
Introduction, , various crack detection techniques, Examination through Human Senses, Liquid Penetration Inspection, Ultrasonic Testing, Radiographic Imaging, Magnetic Particle Inspection. [6 hrs]

Text Books:

- Kumar Prashant, “Elements of Fracture Mechanics”, Tata McGraw-Hill,2009.
- Maiti S K, “Fracture Mechanics: Fundamentals and Applications”,• Cambridge University Press, 2015.

Reference Books:

- Brook D, “Elementary engineering fracture mechanics’, Springer, 2012.
- Liebowitz H.,” Fracture” Volume I to VII, Academic Press Inc., Nov. 1972.
- Nadai A and Hemp W. S., “Theory of fow and fracture of solids”, McGraw Hill Book Company, 1950.

Departmental Elective- IV
ME (DE) XX001 Mechanical Vibraions and Acoustics

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Model a given vibratory system as SDOF or MDOF system, with or without damping, and with base or force excitation as periodic or aperiodic.
- Evaluate natural frequencies and mode shapes of MDOF and continuous systems using modal analysis and computational methods such as Rayleigh-Ritz method and Holzer method.

- Explain various terminologies used in acoustics and acoustic wave transmission and estimate sound pressure level.
- Summarize the mechanism of hearing by human and principles of Psychoacoustics and noise control.

Unit 1: (5hrs)
Systems with one degree of freedom
Review of one degree of freedom, Energy method, Undamped, damped free and forced vibrations

Unit 2: (6hrs)
General forced response
Impulse response function, response to an arbitrary input, response to an arbitrary periodic input, response to random input, shock spectrum, stability.

Unit 3: (6hrs)
Systems with more than one degree of freedom system
Undamped free vibration: principal modes, semidefinite systems, steady state undamped forced vibrations, damped free vibrations, steady state forced vibrations with damping, influence coefficients, Generalised coordinates and coordinate coupling, principle coordinates, The langrage equation.

Unit 4: (7hrs)
Multi degree of freedom system matrix method
Undamped free vibration: principal modes, Normal coordinates, orthogonality of the principal modes of vibrations, systems with equal frequencies, Natural frequencies and principal modes by matrix iteration. Damped free vibrations, forced vibrations, Eigenvalues and natural frequencies, Modal analysis, modal analysis of the forced response. Design for vibration suppression, Vibration isolation, vibration absorbers

Unit 5: (6hrs)
Entropy
Plane Acoustic waves
Plane acoustic waves, derivation of plane wave equation relationship between acoustic pressure, particle displacement and velocity, velocity of plane acoustic waves, specific acoustic impedance, Sound power, sound intensity, sound pressure and sound intensity levels. Transmission Phenomena, transmission from one fluid medium to another, normal incidence reflection at the surface, of a solid,standing wave patterns.

Unit 6: (8hrs)
Psychoacoustics

Speech, Hearing and Noise, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre.

Text Books

- Francis S. Tse, Ivan E. Morse, Rolland “Mechanical Vibrations” 1963.

- Robert K. Vierck, “Vibration Analysis”1967.
- Inmann Daniel J. ,“Engineering Vibration”, 4th Edition, Pearson,2014.
- Thomson W.T., “Theory of vibrations with applications”, CBS Publishers, Delhi, 2008.
- Rao S.S., “Mechanical Vibrations”, Wiley Publishing Co., 2003.
- G. K. Grover, “Mechanical Vibrations” 1998.
- Kinsler Lawrence E. and Frey Austin R. “Fundamentals of Acoustics”, Wiley Eastern Ltd., 2000

Reference Books

- Timoshenko S, “Vibration problems in Engineering”, Wiley, 1990.
- Meirovitch Leonard, “Fundamentals of vibrations”, McGraw Hill International Edition, 2003.
- Rettinger Michael, “Acoustic Design and Noise Control”, Vol. I & II. , Chemical Publishing Co., New York, 1977.
- Shriniwasan P., “Mechanical Vibration Analysis”, Tata McGraw Hill,1982.

Departmental Elective- IV
ME (DE) XX001 Tribology

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Understand various theories of friction and wear and will be able to apply them to various practical situations.
- Understand the various surface measurement techniques and effect of surface texture on Tribologicalbehavior of a surface.
- Select materials and lubricants to suggest a tribological solution to a particular situation.
- Apply learning of the basics of hydrodynamic bearings.
- Use Raimondi and Boyd charts to design hydrodynamic journal bearing and slider shoe bearing.

Unit 1: **(4hrs)**
Basic concepts & areas of application of tribology

Unit 2: **(6hrs)**
Surface texture and measurement

Unit 3: **(8hrs)**
Theories of friction, Friction control

Unit 4: **(8hrs)**
Wear, types of wear, theories of wear, wear prevention

Unit 5: **(4hrs)**
Tribological properties of bearing materials and lubricants.

Unit 6: **(10 hrs)**
Lubrication Regimes, Hydrodynamic Journal Bearing, Slider shoe bearing, their applications

Text Books

- Principles in Tribology, Edited by J. Halling, 1975
- Bernard J. Hamrock, "Fundamentals of Fluid Film Lubrication", McGraw Hill Publication

Reference Books

- S.K. Basu, B. B. Ahuja, S. N. Sengupta , "Fundamentals of Tribology", EEE, PHI Pvt. Publications Ltd.
- A. Cameron, "Basic Lubrication Theory", Ellis Horwood Ltd, 1981.

Departmental Elective- IV
ME (DE) XX001 Advanced CAD/CAM

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Develop an ability to create automated solid model using CAD Customization.
- understand CAD/CAM data exchange formats
- understand applications of CAD for computer aided Advanced Manufacturing Methods
- understand concept of Product Life Cycle Management (PLM)

Unit 1 **(6hrs)**

Introduction to Python Programming:
Data Types, Variables, Basic Input-Output Operations, Basic Operators. Boolean Values, Conditional Execution, Loops, Lists and List Processing.Writing functions in Python

Unit 2 **(6hrs)**

CAD Customization:
Need of Cad customization. OLE interfaces in CAD/CAM software; Use of General programming interfaces like VB, VBS, VC++, Open GL programming and System dependent programming interfaces like Visual LISP (AutoCAD), GRIP (Unigraphics), Pro-Programming (Pro/Engineer). Creating automated Solid modeling using Customization through API

Unit 3 **(6hrs)**

Data Exchange Formats:
Introduction to CAD/Cam data exchange formats. Direct and Indirect translators. Neutral file formats: Data Exchange format (DXF), Standard Triangular Languages (STL), Initial Graphics Exchange Specification (IGES), 3MF etc.

Unit 4 **(6hrs)**

Surface and Hyper patch Modeling:
Surface modeling methods, twist vector, algebraic and control point based hyper patch modeling techniques

Unit 5 **(7hrs)**

Additive Manufacturing Processes
Models and specifications, Process, working principle, Applications, Advantages and Disadvantages, Case studies of following: Solid-based Rapid Prototyping Systems: Fused Deposition Modeling (FDM), Laminated Object Manufacturing (LOM). Liquid based Rapid Prototyping Systems: Stereo lithography Apparatus (SLA). Powder Based Rapid Prototyping Systems: Selective laser sintering (SLS)

Unit 6 **(4hrs)**

Introduction to Product Life Cycle Management
Background, Overview, Need, Benefits, and Concept of Product Life Cycle, Components / Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement, Threads of PLM- computer aided design (CAD), engineering data management (EDM), Product data management (PDM), computer integrated manufacturing (CIM, comparison of PLM to Engineering resource planning (ERP).

Text Books

- Solid Modelling, MarttiMantilya, Computer Science Press,2014
- Rapid prototyping: Principles and Applications, Chua C.K., Leong K.F. and LIM C.S, World Scientific publications , Third Edition, 2010
- Geometric modeling, Michael Morteanson,John Wiley publication
- Python Programming: An Introduction to Computer Science (3rd Edition), John M. Zelle

Reference Books

- Manuals of Professional CAD software such as Creo Parametric, NX, CATIA
- Additive Manufacturing Technologies, 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, 2013, Gibson, Ian, Rosen, David, Stucker, Brent.

Departmental Elective- IV
ME (DE) XX001 Manufactruring Philosophies

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:

At the end of the course students will be able to:

- Understand the various manufacturing philosophies for the excellence.
- Demonstration of professional and ethical responsibility in the chosen field.
- Realization of the significance of internal and external customer needs and wants.
- Understanding the role of leader in manufacturing and services

Unit I:

Introduction to World Class Manufacturing Manufacturing excellence and competition frame work of WCM- Hall's, Schonberger's Gunn's, Maskell.WCM and Indian manufacturing scenario. [6 hrs]

Unit II:

Total Quality Management Quality definition, Contribution of various quality guru, Customer satisfaction, Continuous improvement, Supplier partnership, performance measures of Quality. [6 hrs]

Unit III:

Tools and Techniques of TQM Matrix diagram, process decision program chart, Management tool- Force field analysis, afnity diagram, Pareto diagram, Histogram, Process fow diagram, why- why analysis, Cause and efect diagram, Benchmarking, Quality function deployment (QFD), ISO 9000, Malcom Baldrig Certificate, European Quality Award certification. [6 hrs]

Unit IV:

JIT Philosophy Just in time, seven waste, Basic element of JIT, KANBAN, PoKaYoKe, 5 S Theory, Implementation of JIT, Value engineering [6 hrs]

Unit V:

Total Productive Maintenance Introduction of maintenance, Learning and implementing TPM, Development Autonomous Group, Training pertaining to TPM, Calculation relation with availability of machine. [6 hrs]

Unit VI:

Business Process Reengineering Service Management, Introduction to concurrent engineering,Introduction to ERP and Supply chain management. [6 hrs]

Text books:

- Barsterfield, “Total Quality Management”, Pearson Publication, ISBN no 13-978-9332534452,Edition 4,2015.
- T.C. Cheng, S. Podolsky Springer “Science & Business Media”, 31-Jul1996 - Business & Economics.

Reference Books:

- B. S. Sahay, K. B. C. Saxena ,”WCM- A strategic Perspective”, Macmillan Publication, ISBN no 13-978-0333934746,2013.
- Mart and Telsang. S ,”Industrial Engineering and Production Management”, Chand Publication, ISBN no 13-978- 8121917735,2006.
- K.C. Arora. S.K ,”Total Quality Management”, Kataria and Sons Publication.
- Barsterfield ,”Total Quality Management”, Pearson Publication, ISBN no 13-978-8185749990,2010.

ME ( ) XX001 Major Project

Teaching Scheme
Practical: 4hrs / week

Examination Scheme
Term Work: 50 marks
Practical/Oral: 50 marks

Course Outcomes:
At the end of the course students will be able to:

The students in a group of not more than FOUR will work under the guidance of the faculty member on the project work undertaken by them. The completion of work, the submission of the report and assessment should be done at the end of Part I (1st Semester).

The project work may consist of,
1. A comprehensive and up-to-date survey of literature related to study of a phenomenon or product.
2. Design of any equipment and / or its fabrication and testing.
3. Critical Analysis of any design or process for optimizing the same.
4. Experimental verification of principles used in applications related to Production Engineering.
5. Software development for particular applications.
6. A combination of the above.

The objective is to prepare the students to examine any design or process or phenomenon from all angles, to encourage the process of independent thinking and working and to expose them to industry. The students may preferably select the project works from their opted elective subjects.

A synopsis of the selected project work (two to three pages typed on A4 size sheets) certified by the project guide, should be submitted before the month of June of year. The synopsis shall be a part of the final project report.

The students should submit the report in a prescribed format, at the end of 1 st semester. The report shall be comprehensive and presented in duplicate, typed on A4 size sheets and bound.

1. Term work will be assessed by the project guide along with one colleague appointed by the Head of Department.

2. The students will be examined orally by the external examiner and the project guide, as the internal examiner. Marks will be awarded on the basis of the work done and performance in the oral examination

Minor in Product Design and Optimization
ME (MI) XX002 Introduction to Optimization Techniques

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Formulate an optimization problem.
- Classify a problem.
- Apply the algorithms for design optimization.
- Test the optimality of an optimum solution

Unit I:

Introduction to optimization Basic principles, optimal problem formulation, classification of optimization problems, Diferences between classical and modern optimization techniques [4 hrs]

Unit II:

One dimensional minimization Optimality criteria, bracketing methods, direct search methods, gradient based search methods [8 hrs]

Unit III:

Multivariable Unconstrained Optimization Optimality criteria, direct search methods, gradient based search methods, applications [8 hrs]

Unit IV:

Constrained optimization KKT conditions, direct search methods, gradient based search methods, applications [8 hrs]

Unit V:

Linear programming Linear problem formulation, simplex method and duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's method [4 hrs]

Unit VI:

Introduction to Genetic Algorithms Operators, method, applications like optimum design of spring, gear box, etc. [4 hrs]

Test Books:

- Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2016
- J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 2014

Reference Books:

- R.C. Johnson, "Optimum Design of Mechanical Elements" , Willey, New York, 2011
- L.C.W. Dixon, Birkhauser, "Non-Linear Optimization - Theory and Algorithms" , Boston, 2005

Honor in Hybrid and Electrical Vehicles
ME (DE) XX001 Hybrid and Electric Vehicle

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- Apply basic principles of hybrid and electric vehicle to design vehicle.
- Select appropriate cycle source of energy for the hybrid electric vehicle based on driving.
- Analyze the power and energy need of the various hybrid electric vehicle.
- Measure and estimate the energy consumption of the Hybrid Vehicles.
- Evaluate energy efficiency of the vehicle for its drive trains.

Unit 1 **(6 hrs)**

Introduction to Electric Vehicle:
History of Electric Vehicles, Development towards 21st Century, Types of Electric Vehicles in use today – Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Motion and Dynamic Equations of the Electric Vehicles: various forces acting on the Vehicle in static and dynamic conditions.

Unit 2 **(6 hrs)**

Induction to Hybrid Electric Vehicle:
Social and environmental importance of hybrid and electric vehicles, impact of modern drivetrains on energy supplies. Hybrid Electric drivetrains: Basic concept of hybrid traction, introduction to various hybrid Drive-train topologies, power flow control in hybrid drive-train topologies, fuel efficiency analysis.

Unit 3 **(8hrs)**

Electric Drive Trains:
Basic concept of electric traction, introduction to various electric drive- train topologies, power flow control in electric drive-train topologies, fuel efficiency analysis. Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.

Unit 4 **(7hrs)**

Types of Storage Systems:
Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage and its analysis, Fuel Cell based energy storage and its analysis, Super Capacitor based energy storage and its analysis, Flywheel based energy storage and its analysis, Hybridization of different energy storage devices. Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology, Calculation for the ratings.

Unit 5 **(7hrs)**

Modelling of Hybrid Electric Vehicle Range:

Driving Cycles, Types of Driving Cycles, Range modelling for Battery Electric Vehicle, Hybrid (ICE & others), Fuel Cell EV, Solar Powered Vehicles. Case study of 2-wheeler, 3-wheeler and 4-wheeled vehicles.

Unit 6 **(7hrs)**

Energy Management Strategies

Introduction to energy management strategies used in hybrid and electric vehicles, classification of different energy management strategies, comparison of different energy management strategies, implementation issues of energy management strategies. Introduction to various charging techniques and schematic of charging stations.

Reference Books:

- James Larminie, J. Lowry, “Electric Vehicle Technology Explaned”, John Wiley & Sons Ltd. 2003.
- M. Ehsani, Y. Gao, S. E. Gay and A. Emadi, “Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design”, CRC Press, 2004.
- S. Onori, L. Serrao and G. Rizzoni, “Hybrid Electric Vehicles: Energy Management Strategies”,Springer, 2015.
- Iqbal Hussein, “Electric and Hybrid Vehicles: Design Fundamentals”, CRC Press, 2003.

List of Open-Source Software/learning website:

- Online course: https://nptel.ac.in/course.html
- Ocw.mit.edu/courses
- https://www.eng.mcmaster.ca/mech/content/electric-and-hybrid-vehicles

Honor in Thermal Stream

ME (HO) XX005 Advanced Heat Transfer

Teaching Scheme
Lectures: 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End– Sem. Exam: 60 marks

Course Outcomes (COs):

At the end of the course students will be able to:

- The students are expected to understand the subject of Heat Transfer in detail with capability to solve Industrial Problems.
- This will also create the base and interest among the students to carry out the Future Research

Unit I: Conduction- one and two dimensional

Unit II: Fins, conduction with heat source, unsteady state heat transfer

Unit III: Natural and forced convection, integral equation, analysis and analogies

Unit IV: Transpiration cooling, ablation heat transfer, boiling, condensation and two phase fow mass transfer, cooling, fuidized bed combustion

Unit V: Heat pipes, Radiation, shape factor, analogy, shields

Unit VI: Radiation of gases & vapours

References:

- J.P. Holman, "Heat Transfer", McGraw Hill Book Company, New York, 1990.
- Incropera and Dewitt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, NewYork, 2000.
- Frank Kreith, "Principles of Heat Transfer", Harper and Row Publishers, New York, 1973.
- Donald Q. Kern "Process Heat Transfer", Tata McGraw Hill Publishing Company Ltd., New Delhi, 1975.
- Gupta and Prakash, "Engineering Heat Transfer", New Chand and Bros, Roorkee (U.P.) India, 1996.
- R.C. Sachdeva "Fundamentals of Engineering Heat and Mass Transfer", Wiley Eastern Ltd., India

Honor in Design Stream
ME (HO) XX006 Stress Analysis

Teaching Scheme
Lectures: 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End– Sem. Exam: 60 marks

Course Outcomes (COs):

At the end of the course students will be able to:

- Apply the tensorial approach of continuum mechanics for complex analysis and comprehend modern research material.
- Synthesis the basic field equations such as equilibrium equations, compatibility and constitutive relationship.
- Evaluate torsion, bending and two dimensional problems employing basic field equations, energy methods and plastic hinges.
- Estimate any complex analysis using proficient FEM software packages with framing correct boundary conditions.

Unit I:

Tensors:
Tensor, transformation of tensorial components, dot and cross product of vectors, eigenvalue problems, Gradient of a scalar, Gauss theorem. Stress Analysis; traction vector, Stress tensor, stress components at a point of a free surface, Principal stresses and principal directions, Mohr circle, theories of yielding. [6 hrs]

Unit II:

Deformation and strain:
Deformation gradient, polar decomposition theorem, Cauchy-Green tensor, Green strain tensor, small displacement strain tensor, engineering and tensorial strains, transformation of strain components in cylindrical coordinates. Compatibility relations in strain components and in stress components, conservation laws; conservation of linear momentum and angular momentum, equilibrium equations in Cartesian and cylindrical coordinates. [6 hrs]

Unit III:

Constitutive relations and Linear Elasticity:
Uniaxial stress tension test, true stress and true strain, strain energy density, generalized Hooks law, Isotropic materials, boundary conditions, principle of superposition, uniqueness, Saint-Venant's principle, Dislocations in crystalline materials, Bauschingerefect. [6 hrs]

Unit IV:

Two dimensional problems and Energy methods:
Plane stress, Plane strain, Biharmonic equation and Airy's stress function, Biharmonic equation in cylindrical coordinates, concentrated load on half space, Energy methods; strain energy and complimentary energy, principle of virtual work, principle of minimum potential energy, Rayleigh Ritz methods, Castiglione's theorems. [6 hrs]

Unit V:

Torsion:
Polar rotation, Prandlt stress approach, torsion of non-circular crosssections, Prandlt membrane analogy, torsion of thin plates and thin wall tubes. [6 hrs]

Unit VI:

Bending and Shearing:
Short beam, bending of asymmetrical sections, shear stress on a thin wall open section [6 hrs]

Text Books:

- Arbindkumar Singh, "Mechanics of solids", Prentice Hall of India Pvt. Ltd, New Delhi, 2007.
- Srinath L.S, "Advanced Mechanics of Solids", Tata McGraw Hill Education, New Delhi, 2009.

Reference Books:

- Sadd Martin H., “Elasticity: Theory, Applications and Numerics”, Elsevier, 2014.
- Boresi A.P. and K. P. Chong, “Elasticity in Engineering Mechanics”, Second Edition, John Wiley & Sons, 2000.
- Budynas R. G., “Advance strength and Applied Stress Analysis”, Second Edition, McGraw Hill, 1999.
- Dally J. W. and Riley W.F., “Experimental Stress Analysis”, McGraw Hill International, 2005.

Minor in Product Design and Optimization
ME (MI) XX005 Introduction to CAD/CAM

Teaching Scheme
Lectures: 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End– Sem. Exam: 60 marks

Course Outcomes (COs):

At the end of the course students will be able to:

- Recall the fundamentals of CAD/CAM
- Compare and Represent 2-D and 3-D entities
- Apply transform techniques on 2-D and 3-D entities
- Examine CNC program for production of components
- Express the principles and methods of Rapid Prototyping

Unit I:

Fundamentals of CAD/CAM Product cycle and scope of CAD/CAM/CIM in product cycle, Features of CAD/CAM Hardware and software. [3hrs]

Unit II:

Representation of Curves and surfaces Introduction to Analytic Curves, Synthetic Curves: Hermite Cubic Spline, Bezier Curve, B-Spline curve. Surface Representation: Synthetic Surfaces [5 hrs]

Unit III:

Solid Modeling 2D Vs 3D modeling, Comparison of Wireframe, surface and solid modeling techniques, Geometry Vs Topology, Requirements of Solid Modeling, Constructive Solid Geometry (CSG), Boundary Representation (B-rep), etc. [5 hrs]

Unit IV:

Geometric Transformation 2D geometric transformations, Homogeneous co-ordinate representation, Composite transformations, 3D transformations, geometric mapping [3 hrs]

Unit V:

Computer Numerical Control and Part Programming Introduction to NC/CNC/DNC machines, Classification of NC systems, Axis nomenclature, Interpolation, features of CNC controllers, Types of CNC machines, Construction features of CNC machines, Manual Part Programming, , NC word format, Details of G and M codes, Canned cycles, subroutines and Do loops, Tool radius and length compensations [7 hrs]

Unit VI:

Rapid Prototyping and Manufacturing Introduction to Rapid Prototyping, rapid tooling and rapid manufacturing. Process of rapid prototyping. Diferent techniques of Rapid prototyping and their applications. [3 hrs]

Text Books:

- Ibrahim Zeid ,CAD/CAM Theory and Practice, , Tata McGraw-Hill
- Publishing Company Ltd., New Delhi,2012 Dacid F. Rogers, J Alan Adams, Mathematical Elements for Computer
- Graphics, McGraw-Hill publishing Company Ltd.,2001 Chougule N.K., CAD/CAM/CAE, Scitech Publications Ltd, 2017

Reference Books:

- M.E. Mortenson, Geometric Modelling , Wiley, 2016
- Bedworth, Wolfe & Henderson Computer Aided Design & Manufacturing , McGraw Hill, 2003

Honor in Hybrid and Electric Vehicle
ME (HO) XX005 Automotive Transmission and Control

Teaching Scheme
Lectures: 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End– Sem. Exam: 60 marks

Course Outcomes (COs):

At the end of the course students will be able to:

- Understand basics of automotive transmission.
- Understand shift mechanism and clutch control.
- Get familiar with function development of transmission control systems.
- Understand various types of transmission such as AT, AMT, MT.

Unit 1

Introduction to Automotive transmission:
Working principle and construction of Automotive Transmissions, Types of automotive transmissions, Manual Transmissions, CVT, DCT

Unit 2

Transmission System Design:
Transmission requirement in a vehicle, gear ratios, Selecting the Ratios, Overall Gear Ratio, Selecting the Largest Powertrain Ratio, Selecting the Smallest Powertrain Ratio, Final Ratio. Selecting the Intermediate Gears, matching of powertrain.

Unit 3

Automated Manual Transmission (AMT) & Automatic Transmission (AT):
Introduction to Automated manual transmissions, working and construction, different configurations of AMT, actuators in AMT, Automatic transmission, working and construction, shifting strategies, features of AMT & AT, comparison with MT

Unit 4

Transmission Control System:
Introduction to Transmission Control System, Transmission control unit, Function Development of Transmission Control System, Sensors and Actuators

Unit 5

EV transmissions:
Requirements of transmission in electric vehicle, features of EV transmission, types, configurations, performance parameters , design consideration for EV transmission,

Unit 6

Hybrid Vehicle Transmission:
HEV requirements of torque, different types of configurations in HEV, performance of hybrid transmissions, design parameters of HEV transmission systems.

References:

- Vehicle Powertrain Systems, BehroozMashadi , David Crolla, John Wiley & Sons, Ltd, 2012

- Automotive Engineering Powertrain, Chassis System and Vehicle Body, David Crolla, Butterworth-Heinemann, 2009
- Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives 1st Edition, Chris Mi , M. AbulMasrur , David Wenzhong Gao , Wiley; 2011
- Electric Vehicle Technology Explained 1st Edition, James Larminie, John Lowry , Wiley; 2003.

Honor in Thermal Stream
ME (HO) XX005 Modeling of IC Engine

Teaching Scheme	**Examination Scheme**
Lectures: 3hrs / week	Internal Test 1: 20 marks
	Internal Test 2: 20 marks
	End– Sem. Exam: 60 marks

Course Outcomes (COs):

At the end of the course students will be able to:

- Develop and calibrate engine models
- Develop and calibrate single and double zone combustion models
- Analyse zero dimensional Models

Unit I:

Fundamentals:

Governing equations, Equilibrium charts of combustion chemistry, chemical reaction rates, and approaches of modeling, model building and integration methods, gas exchange through valves, exhaust gas recirculation, valve lift curves. [8 hrs]

Unit II:

Thermodynamic Combustion Models of CI Engines:

Single zone models, premixed and difusive combustion models, combustion heat release using wiebe function, wall heat transfer correlations, ignition delay, internal energy estimations, two zone model, application of heat release analysis. [10 hrs]

Unit III:

Fuel spraybehavior:

Fuel injection, injection characteristics, spray structure, fuel atomization, droplet turbulence interactions, droplet impingement on walls. [8hrs]

Unit IV:

Mathematical models of SI Engines:

Simulation of Otto cycle at full throttle, part throttle and supercharged conditions. Progressive combustion, Autoignitionmodeling, single zone models, mass burning rate estimation, SI Engine with stratified charge. Friction in pumping, piston assembly, bearings and valve train etc. friction estimation for warm and warm up engines. [10hrs]

References:

- Haywood, "I.C. Engines", McGraw Hill,2017.
- Ramos J, "Internal Combustion Engine Modeling". CRC Press,1989
- C. D. Rakopoulos and E. G. Giakoumis, Evangelos G. "Diesel Engine Transient Operations, Springer ,2009.
- V. Ganeshan, "Computer simulation of spark engine processes", Universities Press, 1996.
- P.A. Lakshminarayanan and Y. V. Aghav, " Modelling Diesel Combustion" Springer, 2010
- Bernard Challen and RodicaBaranescu, "Diesel Engine Reference Book" Butterworth-Heinemann, 1999.

Honor in Design Stream
ME (HO) XX006 Advanced Vibration and Acoustics

Teaching Scheme
Lectures: 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End– Sem. Exam: 60 marks

Course Outcomes (COs):
At the end of the course students will be able to:

Unit I

Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function. [6 hrs]

Unit II

Multi degree of freedom systems, Free, damped and forced vibrations of two degree of freedom systems, Eigen values and Eigen vectors, normal modes and their properties, mode summation method, use of Lagrange's equations to derive the equations of motion. [6 hrs]

Unit III

Continuous Systems, Vibrations of strings, bars, shafts and beams, discretised models of continuous systems and their solutions using Rayleigh – Ritz method, Mode summation method. [6 hrs]

Unit IV

Vibration Control, Methods of vibration control, Non-linear vibrations, Systems with non-linear elastic properties, principle of superposition, Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Dunkerley's methods, matrix iteration method for eigen-value calculations, Holzer's method. [6 hrs]

Unit V

Plane and Spherical acoustic waves, Transmission Phenomena, transmission from one fuid medium to another, normal incidence, refection at the surface of a solid, standing wave patterns, transmission through three media, Resonators and filters, Absorption of sound waves in fuids : Phase log between pressure and condensation, viscous absorption of plane waves, heat conduction as a source of acoustic attenuation. [6 hrs]

Unit VI

Speech, Hearing and Noise, The voice mechanism, acoustic power output of a speech, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre, beats, aural harmonics and combination tones, masking by pure tones, masking by noise. [6 hrs]

References:

- Thomson W.T., "Theory of Vibrations with applications", George Allen and Unwh Ltd. London, 1981.
- S.S. Rao, Addison, "Mechanical Vibrations", Wesley Publishing Co., 1990.
- Leonard Meirovitch, "Fundamentals of vibrations", McGraw Hill International Edition.
- S. Timoshenko, "Vibration problems in Engineering", Wiley, 1974.
- Lawrence E. Kinsler and Austin R.Frey, "Fundamentals of acoustics", Wiley Eastern Ltd., 1987.
- Michael Rettinger, "Acoustic Design and Noise Control", Vol. I & II. , Chemical Publishing Co., New York, 1977.

Interdisciplinary Open Course (IOC)
ME (DE) XX001 Air Conditioning

Teaching Scheme
Lectures : 3hrs / week

Examination Scheme
Internal Test 1: 20 marks
Internal Test 2: 20 marks
End Sem. Exam: 60 marks

Course Outcomes:
At the end of the course students will be able to:

- To understand the concepts of Psychometry.
- To know working of various Air-conditioning systems.
- To estimate cooling load for various applications.

- To design the A.C. systems.
- To design duct system for a central A.C.systems.

Unit 1 **[10hrs]**

Psychrometry:
Introduction, Applications of Air conditioning, Psychrometry, Psychrometry chart, Typical Air-conditioning process, Adiabatic cooling, Sensible heating, Cooling with humidification Process, Heating and Humidification, Adiabatic mixing of air streams, Air washer, Chemical dehumidification (Numerical Treatment).

Unit 2 **[6hrs]**

Air-conditioning systems:
Introduction ,Classification of Air-conditioning systems, Unitary systems, Central Classification of Air-conditioning systems, Reheat system, Multizone system, Dual Duct system, Variable Air Volume system (VAV) system, All – air and water systems, Unitary Vs Central systems.

Unit 3 **[8hrs]**

Cooling Load Estimation:
Introduction, Comfort, Human comfort chart, Outside Design conditions, Sources of heat load ,conduction through Exterior structures, Heat gain through glass , infiltration, ventilation, outside air load , heat load from people, Lightning, heat gain from equipment, System heat gain room cooling loads, cooling coil load.

Unit 4 **[6hrs]**

Designing the Air-Conditioning Systems:
Psychometric analysis of Air-conditioning systems, Summerairconditing systems provided with Ventilation air, Room sensible heat factor (RSHF).

Unit 5 **[5hrs]**

Air-conditioning Components:
Cooling coil, Heating coils, Air cleaning devices, Humidifiers, Fan, Air distribution systems.

Unit 6 **[5hrs]**

Duct Design:
Introduction , classification ,Duct materials, Continuity equation , Energy equation for pipe flow, total static velocity pressure , Static region , Pressure loss in duct Rectangular sections equivalent to circular duct. Dynamic losses in duct, Methods of duct design, Duct arrangement systems.

Text Books

- R.J.Dossat, “Principles of Refrigeration”, Pearson Education Asia, 2001
- C.P.Arora, “Refrigeration and Air-conditioning”, Tata McGraw-Hill, 2000
- Stoecker& Jones, “Refrigeration and Air-conditioning”, McGraw Hill Book Company, New

York, 1982.
- S.N. Sapali “Refrigeration and Air-conditioning”, PHI, 2016

Reference Books

- J.L.Threlkeld, “Thermal Environmental Engineering”, Prentice Hall, 1970.
- W.F.Stoecker, “Industrial Refrigeration Handbook”, McGraw-Hill, 1998.
- P.C.Koelet, “Industrial Refrigeration: Principles, Design and Applications”, Macmillan, 1992
- ASHRAE HANDBOOKS (i) Fundamentals of Refrigeration.
- “Handbook of air-conditioning system design”, Carrier Incorporation, McGraw Hill Book Co.,U.S.A, 1965.
- Jones W.P., “Air Conditioning Engineering”, Edward Arnold Publishers Ltd., London, 1984.
- Hainer R.W., “Control Systems for Heating, Ventilation and Air-Conditioning”, Van Nostrand