CHHATRAPATI SHAHU JI MAHARAJ UNIVERSITY

KANPUR

SYLLABUS

(Diploma in Mechanical Engineering)

MECHANICAL ENGINEERING

UNIVERSITY INSTITUTE OF ENGINEERING & TECHNOLOGY

SCHOOL OF ENGINEERING & TECHNOLOGY

Semester I
(Common to all Branches)

Sl. No	Category of Course	Code No.	Course Title	Hours per week			Total contact hrs/ week	Cred-its
				L	T	P		
1.	Basic Science	BS101	Mathematics-I	2	1	0	3	3
2.	Basic Science	BS103	Applied Physics-I	2	1	0	3	3
3.	Basic Science	BS105	Applied Chemistry	2	1	0	3	3
4.	Humanities & Social Science	HS101	Communication Skills in English	2	0	0	2	2
5.	Engineering Science	ES101	Engineering Graphics	0	0	3	3	1.5
6.	Engineering Science	ES103	Engineering Workshop Practice	0	0	3	3	1.5
7.	Basic Science	BS107	Applied Physics-I Lab	0	0	2	2	1
8.	Basic Science	BS109	Applied Chemistry Lab	0	0	2	2	1
9.	Humanities & Social Science	HS103	Sports and Yoga	0	0	2	2	1
10.	Humanities & Social Science	HS105	Communication Skills in English Lab	0	0	2	2	1
	Total Credits							**18**

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Semester II
(Common to all Branches)

Sl. No	Category of Course	Code No.	Course Title	Hours per week			Total contact hrs/ week	Cred-its
				L	T	P		
1	Basic Science	BS102	Mathematics-II	3	1	0	4	4
2	Basic Science	BS104	Applied Physics-II	2	1	0	3	3
3	Engineering Science	ES102	Introduction to IT Systems	2	0	0	2	2
4	Engineering Science	ES104	Fundamentals of Electrical & Electronics Engineering	2	1	0	3	3
5	Engineering Science	ES106	Engineering Mechanics	2	1	0	3	3
6	Basic Science	BS106	Applied Physics-II Lab	0	0	2	2	1
7	Engineering Science	ES108	Introduction to IT Systems Lab	0	0	4	4	2
8	Engineering Science	ES110	Fundamentals of Electrical & Electronics Engineering Lab	0	0	2	2	1
9	Engineering Science	ES112	Engineering Mechanics Lab	0	0	2	2	1
10	Audit	AU102	Environmental Science	2	0	0	2	0
Total Credits								**20**

5.3 Semester-wise Detailed Curriculum
Semester III

Sl. No	Category	Code No.	Course Title	Hours per week			Total contact hrs/ week	Credits
				L	T	P		
1	Program core course	MEPC201	Basic Mechanical Engineering	3	1	0	4	4
2	Program core course	MEPC203	Computer Aided Machine Drawing Practice	0	0	4	4	2
3	Program core course	MEPC205	Material Science & Engineering	3	0	0	3	3
4	Program core course	MEPC207	Fluid Mechanics & Hydraulic Machinery	2	1	0	3	3
5	Program core course	MEPC209	Manufacturing Engineering	3	0	0	3	3
6	Program core course	MEPC211	Thermal Engineering - I	3	0	0	3	3
7	Program core course	MEPC213	Manufacturing Engineering Lab-I	0	0	2	2	1
8	Program core course	MEPC215	Fluid Mechanics & Hydraulic Machinery Lab	0	0	2	2	1
9	Program core course	MEPC217	Thermal Engineering Lab-I	0	0	2	2	1
10	Summer Internship-I (4 weeks) after II[nd] Sem	SI201	Internship	0	0	0	0	2
Total				**14**	**2**	**10**	**26**	**23**

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Semester IV

Sl. No	Category	Code No.	Course Title	Hours per week			Total contact hrs/ week	Credits
				L	T	P		
1	Program core course	MEPC202	Measurements & Metrology	2	1	0	3	3
2	Program core course	MEPC204	Strength of Materials	2	1	0	3	3
3	Program core course	MEPC206	Thermal Engineering - II	2	1	0	3	3
4	Program Elective course	MEPE###	Any one Programme Elective	3	0	0	3	3
5	Program Elective course	MEPE###	Any one Programme Elective	3	0	0	3	3
6	Program core course	MEPC208	Material Testing Lab	0	0	3	3	1.5
7	Program core course	MEPC210	Measurements & Metrology Lab	0	0	2	2	1
8	Program core course	MEPC212	Thermal Engineering Lab-II	0	0	3	3	1.5
9	Minor Project	PR202		0	0	4	4	2
10	Mandatory Course	AU202	Essence of Indian Knowledge and Tradition	2	0	0	2	0
Total				**14**	**3**	**12**	**29**	**21**

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Semester V.

Sl. No	Category	Code No.	Course Title	Hours per week			Total contact hrs	Credits
				L	T	P		
1	Program core course	MEPC301	Advanced Manufacturing Processes	3	0	0	3	3
2	Program core course	MEPC303	Theory of Machines & Mechanisms	2	1	0	3	3
3	Program core course	MEPC305	Industrial Engineering & Management	3	0	0	3	3
4	Program Elective course	MEPE###	Any one Programme Elective	3	0	0	3	3
5	Program Elective course	MEPE###	Any one Programme Elective	3	0	0	3	3
6	Open Elective	**OE###	Any one Open Elective	3	0	0	3	3
7	Program core course	MEPC307	CAD/CAM Lab	0	0	2	2	1
8	Program core course	MEPC309	Manufacturing Engineering Lab-II	0	0	2	2	1
9	Summer Internship-II (6 weeks) after IVth Sem	SI301		0	0	0	0	3
10	Major Project	PR302		0	0	2	2	^
Total				17	1	6	24	20+3

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Semester VI

Sl. No	Category	Code No.	Course Title	Hours per week			Total contact hrs	Credits
				L	T	P		
1	Program core course	MEPC302	Design of Machine Elements	2	1	0	3	3
2	Program core course	MEPC304	Production & Operations Man-agement	3	0	0	3	3
3	Humanities and Social Science course	HS302	Entrepreneurship and Start-ups	3	1	0	4	4
4	Open Elective	**OE###	Any one Open Elective	3	0	0	3	3
5	Open Elective	**OE###	Any one Open Elective	3	0	0	3	3
6	Mandatory Course	AU302	Indian Constitu-tion	2	0	0	2	0
7	Major Project	PR302		0	0	6	6	4^
8	Seminar	SE302		1	0	0	1	1
Total				**17**	**2**	**6**	**25**	**21**

^one credit is carried forward from the Vth semester major project evaluation.

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5.1 List of Programme Core Courses [PC]

S. No	Code No.	Course Title	Hours per week			Semester	Credits
			L	T	P		
1	MEPC201	Basic Mechanical Engineering	3	1	0	III	4
2	MEPC203	Computer Aided Machine Drawing Practice	0	0	4	III	2
3	MEPC205	Material Science & Engineering	3	0	0	III	3
4	MEPC207	Fluid Mechanics & Hydraulic Machinery	2	1	0	III	3
5	MEPC209	Manufacturing Engineering	3	0	0	III	3
6	MEPC211	Thermal Engineering - I	3	0	0	III	3
7	MEPC213	Manufacturing Engineering Lab-I	0	0	2	III	1
8	MEPC215	Fluid Mechanics & Hydraulic Machinery Lab	0	0	2	III	1
9	MEPC217	Thermal Engineering Lab-I	0	0	2	III	1
10	MEPC202	Measurements & Metrology	2	1	0	IV	3
11	MEPC204	Strength of Materials	2	1	0	IV	3
12	MEPC206	Thermal Engineering - II	2	1	0	IV	3
13	MEPC208	Material Testing Lab	0	0	3	IV	1.5
14	MEPC210	Measurements & Metrology Lab	0	0	2	IV	1
15	MEPC212	Thermal Engineering Lab-II	0	0	3	IV	1.5
16	MEPC301	Advanced Manufacturing Processes	3	0	0	V	3
17	MEPC303	Theory of Machines & Mechanisms	2	1	0	V	3
18	MEPC305	Industrial Engineering & Management	3	0	0	V	3
19	MEPC307	CAD/CAM Lab	0	0	2	V	1
20	MEPC309	Manufacturing Engineering Lab-II	0	0	2	V	1
21	MEPC302	Design of Machine Elements	2	1	0	VI	3
22	MEPC304	Production & Operations Management	3	0	0	VI	3
Total Credits							**55**

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5.2 List of Program Elective Courses [PE]

S.No	Code No.	Course Title	Hours per week			Semester	Credits
			L	T	P		
1	MEPE###	Tool Engineering	3	0	0	IV / V	3
2	MEPE###	Computer Integrated Manufacturing	3	0	0	IV / V	3
3	MEPE###	Computer Aided Design and Manufacturing	3	0	0	IV / V	3
4	MEPE###	Industrial Robotics & Automation	3	0	0	IV / V	3
5	MEPE###	Heat Transfer	3	0	0	IV / V	3
6	MEPE###	Refrigeration & Air-conditioning	3	0	0	IV / V	3
7	MEPE###	Automobile Engineering	3	0	0	IV / V	3
8	MEPE###	Power Plant Engineering	3	0	0	IV / V	3
9	MEPE###	Farm Equipment & Farm Machinery	3	0	0	IV / V	3
10	MEPE###	Material Handling Systems	3	0	0	IV / V	3
11	MEPE###	Hybrid Vehicles	3	0	0	IV / V	3
12	MEPE###	Mechatronics	3	0	0	IV / V	3
Total Credits							**12**

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Manufacturing Technology

S.No	Code No.	Course Title	Hours per week			Semester	Credits
			L	T	P		
1	MEPE###	Tool Engineering	3	0	0	IV / V	3
2	MEPE###	Computer Integrated Manufacturing	3	0	0	IV / V	3
3	MEPE###	Computer Aided Design and Manufacturing	3	0	0	IV / V	3
4	MEPE###	Industrial Robotics & Automation	3	0	0	IV / V	3

Thermal Engineering

S.No	Code No.	Course Title	Hours per week			Semester	Credits
			L	T	P		
1	MEPE###	Heat Transfer	3	0	0	IV / V	3
2	MEPE###	Refrigeration & Air-conditioning	3	0	0	IV / V	3
3	MEPE###	Automobile Engineering	3	0	0	IV / V	3
4	MEPE###	Power Plant Engineering	3	0	0	IV / V	3

Applied Courses in Mechanical Engineering

S.No	Code No.	Course Title	Hours per week			Semester	Credits
			L	T	P		
1	MEPE###	Farm Equipment & Farm Machinery	3	0	0	IV / V	3
2	MEPE###	Material Handling Systems	3	0	0	IV / V	3
3	MEPE###	Hybrid Vehicles	3	0	0	IV / V	3
4	MEPE###	Mechatronics	3	0	0	IV / V	3

Note: MEPE### to be assigned as per the course offered in a particular semester

Semester III

Course Code	:	MEPC201
Course Title	:	BASIC MECHANICAL ENGINEERING
Number of Credits	:	4 (L: 3, T: 1, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- To understand General Principles of Mechanical Engineering.
- To understand laws of thermodynamics, thermal and thermodynamic Processes.
- To understand working principles of power developing and power absorbing devices.
- To understand basic materials and manufacturing processes.

Course Content:

UNIT-I: Introduction to Thermodynamics - Role of Thermodynamics in Engineering and Science, Types of Systems, Thermodynamic Equilibrium, Properties, State, Process and Cycle, Elementary introduction to Zeroth, First and Second laws of thermodynamics, Heat and Work Interactions for various non-flow and flow processes; Concept of Heat Engine, Heat Pump & Refrigerator, Efficiency/ COP; Kelvin-Planck and Clausius Statements, Carnot Cycle, Carnot Efficiency, T-S and P-V Diagrams, Concept of Entropy (Definition only).

Unit-II: Heat transfer & Thermal Power Plant: Modes of Heat Transfer; Conduction: Composite Walls and Cylinders, Combined Conduction and Convection: Overall Heat Transfer Co-efficient, Simple Numerical Problems: Thermal Power Plant Layout; Rankine Cycle; Fire Tube and Water Tube boilers, Babcock & Wilcox, Cochran Boilers;

Unit-III: Steam Turbines: Impulse and Reaction Turbines; Condensers: Jet & Surface Condensers, Cooling Towers; **Internal Combustion Engines and Refrigeration:** Otto, Diesel and Dual cycles; P-V and T-S Diagrams; IC Engines: 2 - Stroke and 4 - Stroke I.C. Engines, S.I. and C.I. Engines.

Unit-IV: Materials and Manufacturing Processes: Engineering Materials, Classification and their Properties; Metal Casting, Moulding, Patterns, Metal Working: Hot Working and Cold Working, Metal Forming: Extrusion, Forging, Rolling, Drawing, Gas Welding, Arc Welding, Soldering, and Brazing.

Unit-V: Machine Tools and Machining Processes: Machine Tools: Lathe Machine and types, Lathe Operations, Milling Machine and types, Milling Operations, Shaper and Planer Machines: Differences, Quick-Return Motion Mechanism, Drilling Machine: Operations, Grinding Machine: Operations

Reference Books:

1. Basic Mechanical Engineering – M.P. Poonia & S.C. Sharma, Khanna Publishing House, Delhi
2. Elements of Mechanical Engineering – M. L. Mathur, F. S. Mehta and R. P. Tiwari, Jain Brothers, New Delhi
3. Engineering Heat Transfer – Gupta & Prakash, Nem Chand & Brothers, New Delhi
4. Workshop Technology (Vol. 1 and 2) – B. S. Raghuvanshi, Dhanpath Rai and Sons, New Delhi.
5. Basic Mechanical Engineering – J Benjamin

6. Elements of Mechanical Engineering – Roy and Choudhary
7. Engineering Thermodynamics – Spalding and Cole

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand basics of thermodynamics and components of a thermal power plant
CO2	Understand basics of heat transfer, refrigeration and internal combustion engines
CO3	Understand mechanism of thermal power plant and boiler operation
CO4	Identify engineering materials, their properties, manufacturing methods encountered in engineering practice
CO5	Understand functions and operations of machine tools including milling, shaping, grinding and lathe machines

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Course Code	:	MEPC203
Course Title	:	COMPUTER AIDED MACHINE DRAWING PRACTICE
Number of Credits	:	2 (L: 0, T: 0, P:4)
Prerequisites	:	Engineering Graphics (ESC101)
Course Category	:	PC

Course Objectives:

- To use computer aided drafting,
- To prepare geometrical model of various machine elements
- To draw the different views of machine elements
- To interpret the drawing in engineering field and illustrate three dimensional objects

Course Content:

S.No.	Topics for practice
I	Introduction to CAD software.
II	Drawing aids and editing commands.
III	Basic dimensioning, hatching, blocks and views.
IV	Isometric drawing, printing and plotting
V	Machine Drawing practice using Auto CAD: Detailed drawings of following machine parts are to be given to the students to assemble and draw the sectional or plain elevations, plans and side views with dimensioning and bill of materials using cad software (12 exrcises). 1) Sleeve & Cotter Joint 2) Spigot & Cotter Joint 3) Knuckle Joint 4) Stuffing Box 5) Screw Jack 6) Foot Step Bearing 7) Universal Coupling 8) Plummer Block 9) Simple Eccentric 10) Machine Vice 11) Connecting Rod 12) Protected Type Flanged Coupling.

Reference Books:

1. Bhatt, N.D., Machine Drawing, Charotar Publishing House, 2003.
2. Sidheswar, N., Kannaiah, P. and Sastry, V.V.S., Machine Drawing, Tata McGraw Hill Book Company, New Delhi, 2000.
3. Kannaih, P., Production Drawing, New Age International , 2009

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand the representation of materials used in machine drawing
CO2	Draw the development of surfaces for sheet metal working applications.
CO3	Draw the machine elements including keys, couplings, cotters, riveted, bolted and welded joints.
CO4	Construct an assembly drawing using part drawings of machine components
CO5	Represent tolerances and the levels of surface finish of machine elements.

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Course Code	:	MEPC205
Course Title	:	MATERIAL SCIENCE & ENGINEERING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- To understand crystal structures and atomic bonds.
- To understand the properties of different types of ferrous metals and alloys.
- To understand the properties of different types of non-ferrous metals and alloys.
- To understand various metallic failures and acquire the knowledge of testing of materials.
- To understand the concept of corrosion and its prevention.

Course Content:

UNIT-I: Crystal structures and Bonds: Unit cell and space lattice: Crystal system: The seven basic crystal systems; Crystal structure for metallic elements: BCC, FCC and HCP; Coordination number for Simple Cubic, BCC and FCC; Atomic radius: definition, atomic radius for Simple Cubic, BCC and FCC; Atomic Packing Factor for Simple Cubic, BCC, FCC and HCP; Simple problems on finding number of atoms for a unit cell.

Bonds in solids: Classification - primary or chemical bond, secondary or molecular bond; Types of primary bonds: Ionic, Covalent and Metallic Bonds; Types of secondary bonds: Dispersion bond, Dipole bond and Hydrogen bond.

Unit-II: Phase diagrams, Ferrous metals and its Alloys: Isomorphs, eutectic and eutectoid systems; Iron-Carbon binary diagram; Iron and Carbon Steels; flow sheet for production of iron and steel; Iron ores – Pig iron: classification, composition and effects of impurities on iron; Cast Iron: classification, composition, properties and uses; Wrought Iron: properties, uses/applications of wrought Iron; comparison of cast iron, wrought iron and mild steel and high carbon steel; standard commercial grades of steel as per BIS and AISI; Alloy Steels – purpose of alloying; effects of alloying elements – Important alloy steels: Silicon steel, High Speed Steel (HSS), heat resisting steel, spring steel, Stainless Steel (SS): types of SS, applications of SS – magnet steel – composition, properties and uses

Unit-III: Non-ferrous metals and its Alloys: Properties and uses of aluminium, copper, tin, lead, zinc, magnesium and nickel; Copper alloys: Brasses, bronzes – composition, properties and uses; Aluminium alloys: Duralumin, hindalium, magnelium – composition, properties and uses; Nickel alloys: Inconel, monel, nicPerome – composition, properties and uses. Anti-friction/Bearing alloys: Various types of bearing bronzes - Standard commercial grades as per BIS/ASME.

Unit-IV: Failure analysis & Testing of Materials: Introduction to failure analysis; Fracture: ductile fracture, brittle fracture; cleavage; notch sensitivity; fatigue; endurance limit; characteristics of fatigue fracture; variables affecting fatigue life; creep; creep curve; creep fracture; Destructive testing: Tensile testing; compression testing; Hardness testing: Brinell, Rockwell; bend test; torsion test; fatigue test; creep test. Non-destructive testing: Visual Inspection; magnetic particle inspection; liquid penetrant test; ultrasonic inspection; radiography.

Unit-V: Corrosion & Surface Engineering: Nature of corrosion and its causes; Electrochemical reactions; Electrolytes; Factors affecting corrosion: Environment, Material properties and physical conditions; Types of corrosion; Corrosion control: Material selection, environment control and design; Surface engineering processes: Coatings and surface treatments; Cleaning and mechanical finishing of surfaces; Organic coatings; Electroplating and Special metallic plating; Electro polishing and photo-etching ;– Conversion coatings: Oxide, phosphate and chromate coatings; Thin film coatings: PVD and CVD; Surface analysis; Hard-facing, thermal spraying and high-energy processes; Process/material selection. Pollution norms for treating effluents as per standards.

Reference Books:

1. A Text Book of Material Science & Metallurgy – O.P. Khanna, Dhanpath Rai and Sons, New Delhi. 2003.
2. Material Science & Engineering – R.K. Rajput, S.K. Kataria & Sons, New Delhi, 2004.
3. Material Science – R.S. Khurmi, S. Chand & Co. Ltd., New Delhi, 2005.

Course outcomes

At the end of the course, the student will be able to:

CO1	Explain about crystal structures and atomic bonds.
CO2	Describe about classification of ferrous metals and their properties.
CO3	Explain about non-ferrous metals, cutting tool materials and composites along with their properties.
CO4	Describe about the various metallic failures and knowledge in testing of materials.
CO5	Explain the principle of corrosion, their types and its prevention methods along with the various surface engineering processes.

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Course Code	:	MEPC207
Course Title	:	FLUID MECHANICS & HYDRAULIC MACHINERY
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- To understand fluid flow & related machinery for power generation, water supply and irrigation.
- To Select and use appropriate flow measuring device.
- To Select and use appropriate pressure measuring device.
- To understand and analyze the performance of pumps and turbines.

Course Content:

UNIT-I: Properties of fluid: Density, Specific gravity, Specific Weight, Specific Volume, Dynamic Viscosity, Kinematic Viscosity, Surface tension, Capillarity, Vapour Pressure, Compressibility.

Fluid Pressure & Pressure Measurement: Fluid pressure, Pressure head, Pressure intensity, Concept of vacuum and gauge pressures, atmospheric pressure, absolute pressure, Simple and differential manometers, Bourdan pressure gauge, Concept of Total pressure on immersed bodies, center of pressure, Simple problems on Manometers.

Unit-II: Fluid Flow: Types of fluid flows, Path line and Stream line, Continuity equation, Bernoulli's theorem, Principle of operation of Venturimeter, Orifice meter and Pitot tube, Derivations for discharge, coefficient of discharge and numerical problems.

Flow Through Pipes: Laminar and turbulent flows; Darcy's equation and Chezy's equation for frictional losses, Minor losses in pipes, Hydraulic gradient and total gradient line, Numerical problems to estimate major and minor losses

Unit-III: Impact of jets: Impact of jet on fixed vertical, moving vertical flat plates, Impact of jet on curved vanes with special reference to turbines & pumps, Simple Numericals on work done and efficiency.

Unit-IV: Hydraulic Turbines: Layout of hydroelectric power plant, Features of Hydroelectric power plant, Classification of hydraulic turbines, Selection of turbine on the basis of head and discharge available, Construction and working principle of Pelton wheel, Francis and Kaplan turbines, Draft tubes – types and construction, Concept of cavitation in turbines, Calculation of Work done, Power, efficiency of turbines, Unit quantities and simple numericals.

Unit-V: Centrifugal Pumps: Principle of working and applications, Types of casings and impellers, Concept of multistage, Priming and its methods, Cavitation, Manometric head, Work done, Manometric efficiency, Overall efficiency. Numericals on calculations of overall efficiency and power required to drive pumps.

Reciprocating Pumps: Construction, working principle and applications of single and double acting reciprocating pumps, Concept of Slip, Negative slip, Cavitation and separation.

Reference Books:

1. Fluid Mechanics & Hydraulic Machines, S.S. Rattan, Khanna Publishing House, New Delhi
2. Hydraulic, fluid mechanics & fluid machines – Ramamrutham S, Dhanpath Rai and Sons, New Delhi.
3. Hydraulics and fluid mechanics including Hydraulic machines – Modi P.N. and Seth S.M., Standard Book House. New Delhi
4. One Thousand Solved Problems in Fluid Mechanics – K. Subramanya, Tata McGraw Hill.
5. Hydraulic, fluid mechanics & fluid machines – S. Ramamrutham, Dhanpat Rai and Sons, New Delhi
6. Fluid Mechanics and Hydraulic Machines – R. K. Bansal, Laxmi Publications, New Delhi

Course outcomes

At the end of the course, the student will be able to:

CO1	Measure various properties such as pressure, velocity, flow rate using various instruments.
CO2	Calculate different parameters such as co-efficient of friction, power, efficiency etc of various Systems.
CO3	Describe the construction and working of turbines and pumps.
CO4	Test the performance of turbines and pumps.
CO5	Plot characteristics curves of turbines and pumps.

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Course Code	:	MEPC209
Course Title	:	MANUFACTURING ENGINEERING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Basic Mechanical Engineering (MEPC102)
Course Category	:	PC

Course Objectives:

- To understand the importance of cutting fluids & lubricants in machining.
- To study various types of basic production processes. To select, operate and control the appropriate processes for specific applications.
- To understand the concept of gear making and list various gear materials.
- To understand the importance of press tools and understand various die operations.
- To understand Grinding and finishing processes.

Course Content:

UNIT-I: Cutting Fluids & Lubricants: Introduction; Types of cutting fluids, Fluids and coolants required in turning, drilling, shaping, sawing & broaching; Selection of cutting fluids, methods of application of cutting fluid; Classification of lubricants (solid, liquid, gaseous), Properties and applications of lubricants.

Lathe Operations: Types of lathes – light duty, Medium duty and heavy duty geared lathe, CNC lathe; Specifications; Basic parts and their functions; Operations and tools – Turning, parting off, Knurling, facing, Boring, drilling, threading, step turning, taper turning.

Unit-II: Broaching Machines: Introduction to broaching; Types of broaching machines – Horizontal type (Single ram & duplex ram), Vertical type, Pull up, pull down, and push down; Elements of broach tool; broach teeth details; Nomenclature; Tool materials.

Drilling: Classification; Basic parts and their functions; Radial drilling machine; Types of operations; Specifications of drilling machine; Types of drills and reamers.

Unit-III: Welding: Classification; Gas welding techniques; Types of welding flames; Arc Welding – Principle, Equipment, Applications; Shielded metal arc welding; Submerged arc welding; TIG / MIG welding; Resistance welding - Spot welding, Seam welding, Projection welding; Welding defects; Brazing and soldering: Types, Principles, Applications.

Milling: Introduction; Types of milling machines: plain, Universal, vertical; constructional details – specifications; Milling operations: simple, compound and differential indexing; Milling cutters – types; Nomenclature of teeth; Teeth materials; Tool signature of milling cutter; Tool & work holding devices.

Unit-IV: Gear Making: Manufacture of gears – by Casting, Moulding, Stamping, Coining Extruding, Rolling, Machining; Gear generating methods: Gear Shaping with pinion cutter & rack cutter; Gear hobbing; Description of gear hob; Operation of gear hobbing machine; Gear finishing processes; Gear materials and specification; Heat treatment processes applied to gears.

Press working: Types of presses and Specifications, Press working operations - Cutting, bending,

drawing, punching, blanking, notching, lancing; Die set components- punch and die shoe, guide pin, bolster plate, stripper, stock guide, feed stock, pilot; Punch and die clearances for blanking and piercing, effect of clearance.

Unit-V: Grinding and finishing processes: Principles of metal removal by Grinding; Abrasives – Natural & Artificial; Bonds and binding processes: Vitrified, silicate, shellac, rubber, bakelite; Factors affecting the selection of grind wheels: size and shape of wheel, kind of abrasive, grain size, grade and strength of bond, structure of grain, spacing, kinds of bind material; Standard marking systems: Meaning of letters & numbers sequence of marking, Grades of letters; Grinding machines classification: Cylindrical, Surface, Tool & Cutter grinding machines; Construction details; Principle of centreless grinding; Advantages & limitations of centre less grinding; Finishing by grinding: Honing, Lapping, Super finishing; Electroplating: Basic principles, Plating metals, applications; Hot dipping: Galvanizing, Tin coating, Parkerising, Anodizing; Metal spraying: wire process, powder process and applications; Organic coatings: Oil base Paint, Lacquer base, Enamels, Bituminous paints, rubber base coating; Finishing specifications.

Reference Books:

1. Manufacturing technology – P N Rao, Tata McGraw-Hill Publications
2. Elements of workshop Technology (Volume I & II) – S. K. Hajra Chaudary, Bose & Roy, Media Promoters and Publishers Limited.
3. Production Technology (Volume I & II) – O. P. Khanna & Lal, Dhanpat Rai Publications.
4. Fundamental of metal cutting and machine tools– B. L. Juneja, New age international limited.
5. Manufacturing Technology, Metal Cutting & Machine tools– P. N. Rao, Tata McGraw-Hill Publications
6. Production Technology – R.B. Gupta, Satya Prakashan, New Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Know and identify basic manufacturing processes for manufacturing different components.
CO2	Operate & control different machines and equipments.
CO3	Produce jobs as per specified dimensions and inspect the job for specified dimensions.
CO4	Select the specific manufacturing process for getting the desired type of output.
CO5	Adopt safety practices while working on various machines.

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Course Code	:	MEPC211
Course Title	:	THERMAL ENGINEERING - I
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Basic Mechanical Engineering (MEPC102)
Course Category	:	PC

Course Objectives:

- To give a good understanding of and thorough insight into all important aspects of thermal systems, energy control and the general issue of energy.
- To understand the principles & working of various power producing & power absorbing devices.
- To study, analyze and evaluate the operation and the performance of I.C. engines, compres-

sors and refrigerators, to apply pinch technology and to critically analyze and describe the global behavior of integrated thermal systems.

Course Content:

UNIT-I: Sources of Energy: Brief description of energy Sources: Classification of energy sources - Renewable, Non-Renewable; Fossil fuels, including CNG, LPG; Solar Energy: Flat plate and concentrating collectors & its applications (Solar Water Heater, Photovoltaic Cell, Solar Distillation); Wind Energy; Tidal Energy; Ocean Thermal Energy; Geothermal Energy; Biogas, Biomass, Bio-diesel; Hydraulic Energy, Nuclear Energy; Fuel cell.

Unit-II: Internal Combustion Engines: Assumptions made in air standard cycle analysis; Brief description of Carnot, Otto and Diesel cycles with P-V and T-S diagrams; Internal and external combustion engines; advantages of I.C. engines over external combustion engines; classification of I.C. engines; neat sketch of I.C. engine indicating component parts; Function of each part and materials used for the component parts - Cylinder, crank case, crank pin, crank, crank shaft, connecting rod, wrist pin, piston, cooling pins cylinder heads, exhaust valve, inlet valve; Working of four-stroke and two-stroke petrol and diesel engines; Comparison of two stroke and four stroke engines; Comparison of C.I. and S.I. engines; Valve timing and port timing diagrams for four stroke and two stroke engines.

Unit-III: I.C. Engine Systems: Fuel system of Petrol engines; Principle of operation of simple and Zenith carburettors; Fuel system of Diesel engines; Types of injectors and fuel pumps; Cooling system - air cooling, water cooling system with thermo siphon method of circulation and water cooling system with radiator and forced circulation (description with line diagram). Comparison of air cooling and water cooling system; Ignition systems – Battery coil ignition and magneto ignition (description and working). Comparison of two systems; Types of lubricating systems used in I.C. engines with line diagram; Types of governing of I.C. engines – hit and miss method, quantitative method, qualitative method and combination methods of governing; their applications; Objective of super charging.

Unit-IV: Performance of I.C. Engines: Brake power; Indicated power; Frictional power; Brake and Indicated mean effective pressures; Brake and Indicated thermal efficiencies; Mechanical efficiency; Relative efficiency; Performance test; Morse test; Heat balance sheet; Methods of determination of B,P., I.P. and F.P.; Simple numerical problems on performance of I.C. engines.

Unit-V: Air Compressors: Functions of air compressor; Uses of compressed air; Types of air compressors; Single stage reciprocating air compressor - its construction and working (with line diagram) using P-V diagram; Multi stage compressors – Advantages over single stage compressors; Rotary compressors: Centrifugal compressor, axial flow type compressor and vane type compressors.

Refrigeration & Air-conditioning: Refrigeration; Refrigerant; COP; Air Refrigeration system: components, working & applications; Vapour Compression system: components, working & applications; Air conditioning; Classification of Air-conditioning systems; Comfort and Industrial Air-Conditioning; Window Air-Conditioner; Summer Air-Conditioning system, Winter Air-Conditioning system, Year-round Air-Conditioning system.

Reference Books:

1. Introduction to Renewable Energy – Vaughn Nelson, CRC Press
2. Thermal Engineering – P.L. Ballaney, Khanna Publishers, 2002
3. A Course in Thermal Engineering – S. Domkundwar & C.P. Kothandaraman, Dhanpat Rai.
4. Thermal Engineering – R.S. Khurmi and J.K. Gupta, 18th Edition, S. Chand & Co, NewDelhi.
5. Thermal Engineering – R. K. Rajput,8th Edition, Laxmi publications Pvt Ltd, New Delhi.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Know various sources of Energy and their applications.
CO2	Classify I.C. engines and understand their working and constructional features.
CO3	Draw the energy flow diagram of an I.C. engine and evaluate its performance.
CO4	Describe the constructional features of air compressor and working of different air compressors.
CO5	Know the applications of refrigeration and Classify air-conditioning systems.

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Course Code	:	MEPC213
Course Title	:	MANUFACTURING ENGINEERING LAB-I
Number of Credits	:	1.5 (L: 0, T: 0, P: 3)
Prerequisites	:	Basic Mechanical Engineering (MEPC102) Manufacturing Engineering (MEPC207)
Course Category	:	PC

Course Objectives:

- To Practice the casting principles and operations in foundry.
- To Practice the operation of Lathe.
- To Practice the joining of metals using different Welding techniques.

Course Content:

S.No.	Topics for practice
I	Moulding & casting of (i) Connecting rod (ii) Solid bearing (iii) V-Pulley/Gear Pulley
II	Arc welding (i) Lap Joint (ii) Butt Joint (iii) T- Joint
III	Gas welding (i) Lap Joint (ii) Butt Joint
IV	Spot welding (i) Lap Joint
V	Turning Exercise (i) Facing, Step Turning & Chamfering (ii) Step Turning & Taper Turning (iii) Step Turning & Groove Cutting (iv) Step Turning & & Knurling (v) Step Turning & Thread Cutting (vi) Turning and Drilling
VI	Grinding the Lathe Cutting tools to the required angles
VII	Study of Lathe, Drilling machine, shaping machine and slotting machine
VIII	The dismantling some of the components of lathe and then assemble the same
IX	List the faults associated with lathe and its remedies
X	The routine and preventive maintenance procedure for lathe

Reference Books:

1. Elements of Workshop Technology (Volume I & II) – Hajra Chowdry & Bhattacharaya, Media Promoters, 11th Edition, 2007
2. Introduction of Basic Manufacturing Processes and Workshop Technology – Rajendersingh, New age International (P) Ltd. NewDelhi, 2006
3. Workshop Technology – Raghuwanshi, Khanna Publishers. Jain &Gupta, New Delhi, 2002
4. Production Technology – Jain & Gupta, Khanna Publishers, New Delhi, 2006.
5. Production Technology – HMT, 18th edition, Tata McGraw Hill, New Delhi
6. Manufacturing process – Myro N Begman, 5 th edition, Tata McGraw Hill, New Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Prepare a mould sand mix and molten metal and calculate the amount of metal to be poured in the mould
CO2	Centre the job and select the proper tool to perform the job on lathe machine.
CO3	Calculate the taper angle and practice different taper turning methods on lathe.
CO4	Prepare the edges for welding and select the suitable electrode, voltage and current.
CO5	Operate the welding transformer and generator to perform various weld joint operations.

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Course Code	:	MEPC215
Course Title	:	FLUID MECHANICS & HYDRAULIC MACHINERY LAB
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Prerequisites	:	Fluid Mechanics & Hydraulic Machinery(MEPC203)
Course Category	:	PC

Course Objectives:

- To calibrate the given flow measuring device.
- To apply the knowledge acquired in theory subject.
- To analyse the performance of turbines and pumps.

Course Content:

S.No.	Topics for practice
I	Verification of Bernoulli's theorem.
II	Determination of Coefficient of Discharge of Venturimeter.
III	Determination of Coefficient of Discharge, coefficient of contraction and coefficient of velocity of Orificemeter.
IV	Determination of coefficient of friction of flow through pipes.
V	Determination of force exerted by the jet of water on the given vane.
VI	Determination of minor losses of flow through pipes.
VII	Calibration of pressure gauge using dead weight pressure gauge tester.
VIII	Trial on centrifugal pump to determine overall efficiency.
IX	Trial on reciprocating pump to determine overall efficiency.
X	Trial on Pelton wheel to determine overall efficiency.
XI	Trial on Francis/Kaplan turbine to determine overall efficiency.

Reference Books: N. Kumara Swamy, Fluid Mechanics and Machinery Laboratory Manual, Charotar Publishing House Pvt. Ltd., ANAND 388 001, Ed. 2008

Course outcomes:

At the end of the course, the student will be able to:

CO1	Measure various properties such as pressure, velocity, flow rate using various instruments.
CO2	Calculate different parameters such as co-efficient of friction, power, efficiency etc. of various systems.
CO3	Understand the need and importance of calibration of pressure gauges.
CO4	Describe the construction and working of turbines and pumps.
CO5	Test the performance of turbines and pumps and Plot characteristics curves.

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Course Code	:	MEPC217
Course Title	:	Thermal Engineering Lab – I
Number of Credits	:	1 (L:0; T:0; P:2)
Prerequisites	:	Thermal Engineering – I (MEPC207)
Course Category	:	PC

Course Objectives:

- To understand the importance of fuel properties and learn the methods of determination of various properties of fuels.
- To understand the working principles of various methods used in determination of properties of fuels.
- To observe different parts of I.C. engine and understand their working.
- To identify the physical differences between S.I. and C.I. engines and 2-S and 4-S engines.

Course Content:

S.No.	Topics for practice
I	Flash & Fire point tests using Able's/Cleveland/Pensky Martin Apparatus
II	Viscosity measurement usi/Saybolt viscometer
III	Calorific value tests using Bomb Calorimeter (Solid and Liquid fuels) and Junkers Gas Calorimeter (Gaseous fuels)
IV	Carbon residue test using Conradson's apparatus.
V	Assembling and disassembling of I.C. Engines
VI	Port timing diagram of Petrol engine
VII	Port timing diagram of Diesel engine
VIII	Valve timing diagram of Petrol engine
IX	Valve timing diagram of Diesel engine
X	Study of petrol and diesel engine components and Models

Reference Books:

1. Thermal Engineering – P.L. Ballaney, Khanna Publishers, 2002
2. A Course in Thermal Engineering – S. Domkundwar & C.P. Kothandaraman, Dhanpat Rai & Publication New Delhi
3. Thermal Engineering – R.S. Khurmi and J.K. Gupta, 18th Edition, S. Chand & Co, NewDelhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand the determination of flash and fire point of a given sample of fuel using given apparatus(Abels, Cleveland & Penesky martin)
CO2	Understand the determination of Viscosity of a given sample of oil using given apparatus .
CO3	Understand the determination of Calorific value of a given sample of fuel using given apparatus.
CO4	Understand the determination of amount of carbon residue of a given sample of petroleum product.
CO5	Draw VTD /PTD of given I.C. Engine and understand how the processes are controlled during its operation.
CO6	Understand the functions of various parts of IC engines and the working of IC engines.

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SEMESTER IV

Course Code	:	MEPC202
Course Title	:	MEASUREMENTS & METROLOGY
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- To study advances in technology, measurement techniques, types of instrumentation devices, innovations, refinements.
- To study the principles of instrumentation, transducers & measurement of non-electrical parameters like temperature, pressure, flow, speed, force and stress.

Course Content:

UNIT-I: Introduction to measurements: Definition of measurement; Significance of measurement; Methods of measurements: Direct & Indirect; Generalized measuring system; Standards of measurements: Primary & Secondary; Factors influencing selection of measuring instruments; Terms applicable to measuring instruments: Precision and Accuracy, Sensitivity and Repeatability, Range, Threshold, Hysteresis, calibration; Errors in Measurements: Classification of errors, Systematic and Random error.

Measuring instruments: Introduction; Thread measurements: Thread gauge micrometre; Angle measurements: Bevel protractor, Sine Bar; Gauges: plain plug gauge, ring Gauge, snap gauge, limit gauge; Comparators: Characteristics of comparators, Types of comparators; Surface finish: Definition, Terminology of surface finish, Talysurf surface roughness tester; Co-ordinating measuring machine.

Unit-II: Transducers and Strain gauges: Introduction; Transducers: Characteristics, classification of transducers, two coil self-inductance transducer, Piezoelectric transducer; Strain Measurements: Strain gauge, Classification, mounting of strain gauges, Strain gauge rosettes-two and three elements.

Measurement of force, torque, and pressure: Introduction; Force measurement: Spring Balance, Proving ring, Load cell; Torque measurement: Prony brake, Eddy current, Hydraulic dynamometer; Pressure measurement: Mcloed gauge.

Unit-III: Applied mechanical measurements: Speed measurement: Classification of tachometers, Revolution counters, Eddy current tachometers; Displacement measurement: Linear variable Differential transformers (LVDT); Flow measurement: Rotometers, Turbine meter; Temperature measurement: Resistance thermometers, Optical Pyrometer.

Miscellaneous measurements: Humidity measurement: hair hygrometer; Density measurement: hydrometer; Liquid level measurement: sight glass, Float gauge; Biomedical measurement: Sphygmo monometer.

Unit-IV: Limits, Fits & Tolerances: Concept of Limits, Fits, and Tolerances; Selective Assembly; Interchangeability; Hole And Shaft Basis System; Taylor's Principle; Design of Plug; Ring Gauges; IS 919-1993 (Limits, Fits & Tolerances, Gauges} IS 3477-1973; concept of multi gauging and inspection.

Angular Measurement: Concept; Instruments For Angular Measurements; Working and Use of Universal Bevel Protractor, Sine Bar, Spirit Level; Principle of Working of Clinometers; Angle Gauges (With Numerical on Setting of Angle Gauges).

Screw thread Measurements: ISO grade and fits of thread; Errors in threads; Pitch errors; Mea-

surement of different elements such as major diameter, minor diameter, effective diameter, pitch; Two wire method; Thread gauge micrometer; Working principle of floating carriage dial micrometer.

Unit-V: Gear Measurement and Testing: Analytical and functional inspection; Rolling test; Measurement of tooth thickness (constant chord method); Gear tooth vernier; Errors in gears such as backlash, runout, composite.

Machine tool testing: Parallelism; Straightness; Squareness; Coaxiallity; roundness; run out; alignment testing of machine tools as per IS standard procedure.

Reference Books:

1. Mechanical measurements – Beckwith Marangoni and Lienhard, Pearson Education, 6th Ed., 2006.
2. Metrology & Measurement – Anand K Bewoor,Vinay kulakarni, Tata McGraw Hill, New Delhi, 2009
3. Principles of Industrial instrumentation and control systems – Channakesava. R. Alavala, DELMAR cenage learning, 2009.
4. Principles of Engineering Metrology – Rega Rajendra, Jaico publishers, 2008
5. Dimensional Metrology – Connie Dotson, DELMAR, Cenage learning, 2007
6. Instrumentation measurement and analysis – B.C. Nakara, K.K. Chaudary, second edition, Tata cgraw Hill, 2005.
7. Engineering Metrology – R.K. Jain, Khanna Publishers, New Delhi, 2005.
8. A text book of Engineering Metrology – I.C. Gupta, Dhanpat Rai and Sons, New Delhi, 2005
9. Metrology for Engineers – J.F.W. Galyer and C. R. Shotbolt, ELBS
10. Engineering Metrology – K. J. Hume, Kalyani publishers

Course outcomes

At the end of the course, the student will be able to:

CO1	Define accuracy, precision, calibration, sensitivity, repeatability and such relevant terms in metrology.
CO2	Distinguish between various types of errors.
CO3	Understand the principle of operation of an instrument and select suitable measuring device for a particular application.
CO4	Appreciate the concept of calibration of an instrument.
CO5	Analyze and interpret the data obtained from the different measurements processes and present it in the graphical form, statistical form.

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Course Code	:	MEPC204
Course Title	:	STRENGTH OF MATERIALS
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Prerequisites	:	Engineering Mechanics (ESC201)
Course Category	:	PC

Course Objectives:

- To understand the concept of Simple Stresses and Strains.
- To understand the concept of Strain Energy.
- To understand the concept of Shear Force and Bending Moment Diagrams.
- To understand the concept of Theory of Simple Bending and Deflection of Beams.
- To understand the concept of Torsion in Shafts and Springs.
- To understand the concept of Thin Cylindrical Shells.

Course Content:

UNIT-I: Simple Stresses and Strains: Types of forces; Stress, Strain and their nature; Mechanical properties of common engineering materials; Significance of various points on stress – strain diagram for M.S. and C.I. specimens; Significance of factor of safety; Relation between elastic constants; Stress and strain values in bodies of uniform section and of composite section under the influence of normal forces; Thermal stresses in bodies of uniform section and composite sections; Related numerical problems on the above topics.

Strain Energy: Strain energy or resilience, proof resilience and modulus of resilience; Derivation of strain energy for the following cases: i) Gradually applied load, ii) Suddenly applied load, iii) Impact/ shock load; Related numerical problems.

Unit-II: Shear Force & Bending Moment Diagrams: Types of beams with examples: a) Cantilever beam, b) Simply supported beam, c) Over hanging beam, d) Continuous beam, e) Fixed beam; Types of Loads – Point load, UDL and UVL; Definition and explanation of shear force and bending moment; Calculation of shear force and bending moment and drawing the S.F and B.M. diagrams by the analytical method only for the following cases: a) Cantilever with point loads, b) Cantilever with uniformly distributed load, c) Simply supported beam with point loads, d) Simply supported beam with UDL, e) Over hanging beam with point loads, at the centre and at free ends, f) Over hanging beam with UDL throughout, g) Combination of point and UDL for the above; Related numerical problems.

Unit-III: Theory of Simple Bending and Deflection of Beams: Explanation of terms: Neutral layer, Neutral Axis, Modulus of Section, Moment of Resistance, Bending stress, Radius of curvature; Assumptions in theory of simple bending; Bending Equation $M/I = \sigma/Y = E/R$ with derivation; Problems involving calculations of bending stress, modulus of section and moment of resistance; Calculation of safe loads and safe span and dimensions of cross- section; Definition and explanation of deflection as applied to beams; Deflection formulae without proof for cantilever and simply supported beams with point load and UDL only (Standard cases only); Related numerical problems.

Unit-IV: Torsion in Shafts and Springs: Definition and function of shaft; Calculation of polar M.I. for solid and hollow shafts; Assumptions in simple torsion; Derivation of the equation $T/J=f_s/R=G\theta/L$; Problems on design of shaft based on strength and rigidity; Numerical Problems related to comparison of strength and weight of solid and hollow shafts; Classification of springs; Nomenclature of closed coil helical spring; Deflection formula for closed coil helical spring (without derivation); stiffness of spring; Numerical problems on closed coil helical spring to find safe load, deflection, size of coil and number of coils.

Unit-V: Thin Cylindrical Shells: Explanation of longitudinal and hoop stresses in the light of circumferential and longitudinal failure of shell; Derivation of expressions for the longitudinal and hoop stress for seamless and seam shells; Related numerical Problems for safe thickness and safe working pressure.

Reference Books:

1. Strength of Materials – D.S. Bedi, Khanna Book Publishing Co. (P) Ltd., Delhi, 2017
2. Strength of Materials – B.C.Punmia, Ashok Kumar Jain & Arun Kumar Jain, Laxmi Publications, New Delhi, 2013
3. Strength of Materials – S. Ramamrutham, Dhanpat Rai & Publication New Delhi
4. Strength of Materials – R.S. Khurmi, S.Chand Company Ltd. Delhi
5. A Text Book strength of Material– R.K. Bansal, Laxmi Publication New Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Compute stress and strain values and find the changes in axial, lateral and volumetric dimensions of bodies of uniform section and of composite section under the influence of normal forces.
CO2	Calculate thermal stresses, in bodies of uniform section and composite sections.
CO3	Define resilience, proof – resilience and modulus of resilience and obtain expressions for instantaneous stress developed in bodies subjected to different loads.
CO4	Compute shear force and bending moment at any section of beam and draw the S.F. & B.M diagrams of for UDL and Point loads.
CO5	Calculate the safe load, safe span and dimensions of cross section.
CO6	Compare strength and weight of solid and hollow shafts of the same length and material and compute the stress and deflection of the closed coil helical spring.

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Course Code	:	MEPC206
Course Title	:	THERMAL ENGINEERING - II
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Prerequisites	:	Thermal Engineering - I (MEPC205)
Course Category	:	PC

Course Objectives:

- To understand the working and applications of Gas turbines & Jet Propulsion.
- To understand the methods of computing various properties of steam.
- To understand the working of various Steam Boilers, functions of various accessories and mountings of boilers.
- To understand the Working of Steam Nozzles and Steam turbines.
- To understand the necessity of compounding and governing of a turbine.

Course Content:

UNIT-I: Gas Turbines: Air-standard Brayton cycle; Description with p-v and T-S diagrams; Gas turbines Classification: open cycle gas turbines and closed cycle gas turbines; comparison of gas turbine with reciprocating I.C. engines and steam turbines. Applications and limitations of gas turbines; General lay-out of Open cycle constant pressure gas turbine; P-V and T-S diagrams and working; General lay-out of Closed cycle gas turbine; P-V and T-S diagrams and working.

Jet Propulsion: Principle of jet propulsion; Fuels used for jet propulsion; Applications of jet propulsion; Working of a turbojet engine; Principle of Ram effect; Working of a Ram jet engine; Principle of Rocket propulsion; Working principle of a rocket engine; Applications of rocket propulsion; Compar-

ison of jet and rocket propulsions.

Unit-II: Properties of Steam: Formation of steam under constant pressure; Industrial uses of steam; Basic definitions: saturated liquid line, saturated vapour line, liquid region, vapour region, wet region, superheat region, critical point, saturated liquid, saturated vapour, saturation temperature, sensible heat, latent heat, wet steam, dryness fraction, wetness fraction, saturated steam, superheated steam, degree of superheat; Determination of enthalpy, internal energy, internal latent heat, entropy of wet, dry and superheated steam at a given pressure using steam tables and Mollier chart for the following processes: Isochoric process, Isobaric process, Hyperbolic process, Isothermal process, Isentropic process, Throttling process, Polytropic process; Simple direct problems on the above using tables and charts; Steam calorimeters: Separating, throttling, Combined Separating and throttling calorimeters – problems.

Unit-III: Steam Generators: Function and use of steam boilers; Classification of steam boilers with examples; Brief explanation with line sketches of Cochran, Babcock and Wilcox Boilers; Comparison of water tube and fire tube boilers; Description with line sketches and working of modern high pressure boilers Lamont and Benson boilers; Boiler mountings: Pressure gauge, water level indicator, fusible plug, blow down cock, stop valve, safety valve, (dead weight type, spring loaded type, high pressure and low water safety alarm); Boiler accessories: feed pump, economiser, super heater and air pre-heater; Study of steam traps & separators; Explanation of the terms: Actual evaporation, equivalent evaporation, factor of evaporation, boiler horse power and boiler efficiency; Formula for the above terms without proof; Simple direct problems on the above; Draught systems (Natural, forced & induced).

Unit-IV: Steam Nozzles: Flow of steam through nozzle; Velocity of steam at the exit of nozzle in terms of heat drop using analytical method and Mollier chart; Discharge of steam through nozzles; Critical pressure ratio; Methods of calculation of cross-sectional areas at throat and exit for maximum discharge; Effect of friction in nozzles and Super saturated flow in nozzles; Working steam jet injector; Simple numerical problems.

Unit-V: Steam Turbines: Classification of steam turbines with examples; Difference between impulse & reaction turbines; Principle of working of a simple De-lavel turbine with line diagrams- Velocity diagrams; Expression for work done, axial thrust, tangential thrust, blade and diagram efficiency, stage efficiency, nozzle efficiency; Methods of reducing rotor speed; compounding for velocity, for pressure or both pressure and velocity; Working principle with line diagram of a Parson's Reaction turbine–velocity diagrams; Simple problems on single stage impulse turbines (without blade friction) and reaction turbine including data on blade height. Bleeding, re-heating and re-heating factors (Problems omitted); Governing of steam turbines: Throttle, By-pass & Nozzle control governing.

Reference Books:

1. A Course in Thermal Engineering – S. Domkundwar & C.P. Kothandaraman, Dhanpat Rai & Publication, New Delhi
2. Thermal Engineering – R.K. Rajput, Laxmi Publication New Delhi
3. Thermal Engineering – P.L. Ballaney, Khanna Publishers, 2002
4. Treatise on Heat Engineering in MKS and SI Units – V.P. Vasandani & D.S. Kumar, Metropolitan Book Co. Pvt. Ltd, New Delhi.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Explain the working cycle of gas turbines, and the working of Jet and Rocket Engines apart from identifying the fuels used for Jet and Rocket propulsion.
CO2	Compute the work done, enthalpy, internal energy and entropy of steam at given conditions using steam tables and Mollier chart.
CO3	Distinguish between water tube and fire-tube boilers and explain the function all the mountings and accessories.
CO4	Calculate Velocity of steam at the exit of nozzle in terms of heat drop analytically and by using Mollier chart.
CO5	State the necessity of governing and compounding of a turbine.
CO6	Explain the principle of working of a steam turbine and distinguish between the impulse turbines and reaction turbines.

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Course Code	:	MEPC208
Course Title	:	MATERIAL TESTING LAB
Number of Credits	:	1.5 (L: 0, T: 0, P: 3)
Prerequisites	:	Material Science & Engineering (MEPC201) Strength of Materials (MEPC204)
Course Category	:	PC

Course Objectives:

- To identify the type of material based on its grain structure
- To learn the procedure for identifying the cracks in the material
- To understand various material testing methods to determine mechanical properties such as yield stress, Ultimate stress, percentage elongation, Young's Modulus etc.

Course Content:

S.No.	Topics for practice
I	Prepare a specimen and examine the microstructure of the Ferrous and Non- ferrous metals using the Metallurgical Microscope.
II	Detect the cracks in the specimen using (i) Visual inspection and ring test (ii) Die penetration test (iii) Magnetic particle test.
III	Determination of Rockwell's Hardness Number for various materials like mild steel, high carbon steel, brass, copper and aluminium.
IV	Finding the resistance of materials to impact loads by Izod test and Charpy test.
V	Torsion test on mild steel – relation between torque and angle of twist determination of shear modulus and shear stress.
VI	Finding Young's Modulus of Elasticity, yield points, percentage elongation and percentage reduction in area, stress strain diagram plotting, tests on mild steel.
VII	Determination of modulus of rigidity, strain energy, shear stress and stiffness by load deflection method (Open & Closed coil spring)
VIII	Single or double Shear test on M.S. bar to finding the resistance of material to shear load.

Reference Books:

1. Measurement system (Application and Design) – Ernest O Doebelin.
2. Strength of Materials – R.S. Khurmi, S.Chand Company Ltd. Delhi
3. A Text Book strength of Material– R.K. Bansal, Laxmi Publication New Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Identify the given specimen by viewing the micro structure using metallurgical microscope
CO2	Identify the cracks in the specimen using different techniques
CO3	Determine the various types of stress and plot the stress strain diagram for mild steel.
CO4	Determine the torsion, bending, impact and shear values of given materials
CO5	Determine the modulus of rigidity, strain energy, shear stress and stiffness of coil spring

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Course Code	:	MEPC210
Course Title	:	MEASUREMENTS & METROLOGY LAB
Number of Credits	:	1 (L:0, T:0 , P:2)
Prerequisites	:	Measurements & Metrology (MEPC202)
Course Catergory	:	PC

Course Objectives:

- To understand techniques for precise measurement of the dimensions of various objects and shapes.

Course Content:

S.No.	Topics for practice
I	Measure the diameter of a wire using micrometre and compare the result with digital micrometre
II	Measure the angle of the machined surface using sine bar with slip gauges.
III	Measure the angle of a V-block / Taper Shank of Drill / Dovetail using universal bevel protractor.
IV	Measure the dimensions of ground MS flat/cylindrical bush using Vernier Caliper compare with Digital/Dial Vernier Caliper.
V	Measure the geometrical dimensions of V-Thread using thread Vernier gauge.
VI	Measure the thickness of ground MS plates using slip gauges

Reference Books:

1. Engineering Metrology – R. K. Jain
2. Engineering precision metrology – R. C. Gupta
3. A Hand book of Industrial Metrology – ASME

Course outcomes:

At the end of the course, the student will be able to:

CO1	Measure various component of linear measurement using Vernier calipers and Micrometre.
CO2	Measure various component of angle measurement using sine bar and bevel Protractor
CO3	Measure the geometrical dimensions of V-thread and spur gear

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Course Code	:	MEPC212
Course Title	:	THERMAL ENGINEERING LAB-II
Number of Credits	:	1.5 (L: 0, T: 0, P: 3)
Prerequisites	:	Thermal Engineering - I (MEPC207) Thermal Engineering - II (MEPC206)
Course Category	:	PC

Course Objectives:

- To understand the working of boilers, compressors and IC engines.
- To observe various parts of engines and understand their functions.
- To perform various tests on IC engines and calculate performance parameters.
- To understand economical and optimum running conditions of the engines.

Course Content:

S.No.	Topics for practice
I	Study of high pressure boiler with model
II	Study of boiler mountings and accessories
III	Conduct performance test on VCR test rig to determine COP of the refrigerator
IV	Conduct performance test on multi stage reciprocating compressor
V	Conduct Morse test to determine the indicated power of individual cylinders
VI	Conduct Performance test on 2-S CI/SI engine.
VII	Conduct Performance test on 4-S CI/SI engine.
VIII	Conduct Heat balance test on CI/SI engine..
IX	Conduct Economical speed test on 4-S CI/SI engine.
X	Thermal conductivity test on 1) Thick slab 2) Composite wall 3) Thick cylinder
XI	Leak detection of refrigeration equipment
XII	Conduct performance test on A/C test rig to determine COP of the refrigerator

Reference Books:

1. Thermal Engineering – P.L. Ballaney, Khanna Publishers, 2002
2. A Course in Thermal Engineering – S. Domkundwar & C.P. Kothandaraman, Dhanpat Rai & Publication New Delhi
3. Thermal Engineering – R.S. Khurmi and J.K. Gupta, 18th Edition, S. Chand & Co, NewDelhi

Course outcomes

At the end of the course, the student will be able to:

CO1	Evaluate the performance characteristics of single cylinder diesel/petrol engine at different loads and draw the heat balance sheet.
CO2	Find the indicated power of individual cylinders of an engine by using morse test.
CO3	Evaluate the performance characteristics Multi stage air compressor
CO4	Evaluate the co efficient of performance of refrigerator
CO5	Find the thermal conductivity of material

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SEMESTER V

Course Code	:	MEPC301
Course Title	:	ADVANCED MANUFACTURING PROCESSES
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Basic Mechanical Engineering (MEPC102) Manufacturing Engineering (MEPC207)
Course Category	:	PC

Course Objectives:

- To Know the functions of Jigs and Fixtures.
- To know the applications of jig-boring machines.
- To identify different fabrication methods of plastic processing viz., sheet forming, blow moulding, laminating and reinforcing of plastics.
- To distinguish between non-conventional machining and traditional machining processes.
- To know about the advancements in the area of manufacturing and production processes.
- To impart knowledge & skills necessary for working in modern manufacturing environment.
- To get familiarized with working principles and operations performed on non-traditional machines, machining center, SPM, automated machines and maintenance of machine tools.

Course Content:

UNIT-I: Jigs & Fixtures: Definition of jig; Types of jigs: Leaf jig, Box and Handle jig, Template jig, Plate jig, Indexing jig, Universal jig, Vice jigs - constructional details of the above jigs; General consideration in the design of drill jigs; Drill bush; Types of fixtures: Vice fixtures, Milling fixtures, Boring fixtures, Grinding fixtures - constructional details of the above fixtures; Basic principles of location; Locating methods and devices; Basic principles of the clamping; Types of clamps: Strap clamps, Cam clamps, Screw clamps, Toggle clamps, Hydraulic and Pneumatic clamps.

Unit-II: Jig Boring: Introduction; Jig boring on vertical milling machine; Types jig boring machines: Open front machine, Cross rail type machine - constructional details & their working; System of location of holes.

Plastic Processing: Processing of plastics; Moulding processes: Injection moulding, Compression moulding, Transfer moulding; Extruding; Casting; Calendering; Fabrication methods-Sheet forming, Blow moulding, Laminating plastics (sheets, rods & tubes), Reinforcing; Applications of Plastics.

Unit-III: Modern Machining Processes: Introduction – comparison with traditional machining; Ultrasonic Machining: principle, Description of equipment, applications; Electric Discharge Machining: Principle, Description of equipment, Dielectric fluid, tools (electrodes), Process parameters, Output characteristics, applications; Wire cut EDM: Principle, Description of equipment, Controlling parameters; applications; Abrasive Jet Machining: principle, description of equipment, application; Laser Beam Machining: principle, description of equipment, application; Electro Chemical Machining: description of equipment, application.

Unit-IV: CNC Milling Machines: Vertical and horizontal machining center: Constructional features, Axis identification, Electronic control system. Automatic tool changer and tool magazine. CNC programming: Preparatory functions (G code), miscellaneous functions (M code), Part programming including subroutines and canned cycles. Principles of computer aided part programming.

Machine Tool Automation: Introduction and Need; (A) Single spindle automates, transfer lines.

(B) Elements of control system, Limit switches, Proximity switches, Block diagram for feedback and servo control system, Introduction to PLC, Block diagram of PLC.

Unit-V: Special Purpose Machines (SPM): Concept, General elements of SPM, Productivity improvement by SPM, Principles of SPM design.

Maintenance of Machine Tools: Types of maintenance, Repair cycle analysis, Repair complexity, Maintenance manual, Maintenance records, Housekeeping. Introduction to Total Productive Maintenance (TPM).

Reference Books:

1. Production Technology – HMT, Banglore, Tata Mc-Graw Hill
2. CNC machines – Pabla B. S. & M. Adithan, New Age international limited.
3. Non conventional Machining – P. K. Mistra, Narvasa Publishining House
4. Manufacturing Processes – Begman & Amsted, John Willey and Sons.
5. Advanced manufacturing technology – David L. Goetsch
6. Exploring Advanced Manufacturing Technologies – Stephen F. Krar & Arthur Gil, Industrial Press

Course outcomes:

At the end of the course, the student will be able to:

CO1	Know the Operation and control of different advanced machine tools and equipments.
CO2	Produce jobs as per specified requirements by selecting the specific machining process.
CO3	Develop the mind set for modern trends in manufacturing and automation.
CO4	Identify the different fabrication methods viz., sheet forming, blow moulding, laminating and reinforcing of plastics.
CO5	Know different non-traditional machining processes, CNC milling machines, special purpose machines.
CO6	Work as maintenance engineer.

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Course Code	:	MEPC303
Course Title	:	THEORY OF MACHINES & MECHANISMS
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Prerequisites	:	Engineering Mechanics (ESC201)
Course Category	:	PC

Course Objectives:

- To understand different types of cams and their motions and also to draw cam profiles for various motions.
- To understand the mechanism of various types of drives available for transmission of power.
- To understand the design of Brakes, Dynamometers, Bearings and Clutches and their function and working.
- To understand the need for balancing of masses in the same plane
- To Know different types of governors.

Course Content:

UNIT I: Cams and Followers: Concept; Definition and application of Cams and Followers; Classification of Cams and Followers; Different follower motions and their displacement diagrams like uniform velocity, SHM, uniform acceleration and Retardation; Drawing of profile of radial cam with knife-edge and roller follower with and without offset with reciprocating motion (graphical method).

UNIT II: Power Transmission: Types of Drives – Belt, Chain, Rope, Gear drives & their comparison; Belt Drives - flat belt, V– belt & its applications; Material for flat and V-belt; Angle of lap, Belt length. Slip and Creep; Determination of Velocity Ratio, Ratio of tight side and slack side tension; Centrifugal tension and Initial tension; Condition for maximum power transmission (Simple numericals); Chain Drives – Advantages & Disadvantages; Selection of Chain & Sprocket wheels; Methods of lubrication; Gear Drives – Spur gear terminology; Types of gears and gear trains, their selection for different applications; Train value & Velocity ratio for compound, reverted and simple epicyclic gear train; Methods of lubrication; Law of gearing; Rope Drives – Types, applications, advantages & limitations of Steel ropes.

UNIT III: Flywheel and Governors: Flywheel - Concept, function and application of flywheel with the help of turning moment diagram for single cylinder 4-Stroke I.C. Engine (no Numericals); Coefficient of fluctuation of energy, Coefficient of fluctuation of speed and its significance; Governors - Types and explanation with neat sketches (Centrifugal, Watt and Porter); Concept, function and applications & Terminology of Governors; Comparison between Flywheel and Governor.

UNIT IV: Brakes, Dynamometers, Clutches & Bearings: Function of brakes and dynamometers; Types of brakes and Dynamometers; Comparison between brakes and dynamometers; Construction and working of i) shoe brake, ii) Band Brake, iii) Internal expanding shoe brake iv) Disc Brake; Concept of Self Locking & Self energizing brakes; Numerical problems to find braking force and braking torque for shoe & band brakes; Construction and working of i) Rope Brake Dynamometer, ii) Hydraulic Dynamometer, iii) Eddy current Dynamometers; Clutches- Uniform pressure and Uniform Wear theories; Function of Clutch and its application; Construction and working of i) Single plate clutch, ii) Multiplate clutch, iii) Centrifugal Clutch iv) Cone clutch and v) Diaphragm clutch. (Simple numericals on single and Multiplate clutch); Bearings – i) Simple Pivot, ii) Collar Bearing, iii) Conical pivot. Torque & power lost in friction (no derivation). Simple numericals.

UNIT V: Balancing & Vibrations: Concept of balancing; Balancing of single rotating mass; Graphical method for balancing of several masses revolving in same plane; Concept and terminology used in vibrations, Causes of vibrations in machines; their harmful effects and remedies.

Reference Books:

1. Theory of machines – S.S .Rattan ,Tata McGraw-Hill publications.
2. Theory of machines – R.K.Bansal ,Laxmi publications
3. Theory of machines – R.S. Khurmi & J.K.Gupta , S.Chand publications.
4. Dynamics of Machines – J B K Das, Sapna Publications.
5. Theory of machines – Jagdishlal, Bombay Metro – Politan book Ltd.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Know different machine elements and mechanisms.

CO2	Understand Kinematics and Dynamics of different machines and mechanisms.
CO3	Select Suitable Drives and Mechanisms for a particular application.
CO4	Appreciate concept of balancing and Vibration.
CO5	Develop ability to come up with innovative ideas.
CO6	Understand different types of cams and their motions and also draw cam profiles for various motions

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Course Code	:	MEPC305
Course Title	:	INDUSTRIAL ENGINEERING & MANAGEMENT
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- To take the right decisions to optimize resources utilization by improving productivity of the Lands, Buildings, People, Materials, Machines, Money, Methods and Management effectively.
- To eliminate unproductive activities under the control of the Management, Supervisor, worker and the Design of Products and Processes.
- To use the Charts to record the Activities of the people, materials and Equipment to find alternative methods which minimize waste and to implement the best method.

Course Content:

UNIT-I: Plant Engineering: Plant; Selection of site of industry; Plant layout; Principles of a good layout; Types; Process; Product and Fixed position; Techniques to improve Layout; Principles of Material handling equipment; Plant maintenance; Importance; Break down maintenance; Preventive maintenance and Scheduled maintenance.

Plant Safety: Importance; Accident: Causes and Cost of an Accident, Accident Proneness, Prevention of Accidents; Industrial disputes; Settlement of Industrial disputes; Collective bargaining; Conciliation; Mediation; Arbitration; Indian Factories Act 1948 and its provisions related to health, welfare and safety.

UNIT-II: Work Study: Productivity; Standard of living; Method of improving Productivity; Objectives; Importance of good working conditions.

Method Study: Definition; Objectives; Selection of a job for method study; Basic procedure for conduct of Method study; Tools used; Operation process chart; Flow process chart; Two handed process chart; Man Machine chart; String diagram and flow diagram.

Work Measurement: Definition; Basic procedure in making a time study; Employees rating factor; Application of time allowances: Rest, Personal, Process, Special and Policy allowances; Calculation of standard time; Numerical Problems; Basic concept of production study; Techniques of Work Measurement; Ratio delay study; Synthesis from standard data; Analytical estimating and Pre determined Motion Time System (PMTS).

UNIT-III: Production Planning and Control: Introduction; Major functions of Production Planning and Control; Pre planning; Methods of forecasting; Routing and Scheduling; Dispatching and Controlling; Concept of Critical Path Method (CPM); Types of Production: Mass Production, Batch Pro-

duction and Job Order Production; Characteristics; Economic Batch Quantity (EBQ); Principles of Product and Process Planning; Make or Buy decision; Numerical problems.

Quality Control: Definition; Objectives; Types of Inspection: First piece, Floor and Centralized Inspection; Advantages and Disadvantages; Statistical Quality Control; Types of Measurements; Method of Variables; Method of Attributes; Uses of X, R, p and c charts; Operating Characteristics curve (O.C curve); Sampling Inspection; Single and Double Sampling plan; Concept of ISO 9001:2008 Quality Management System Registration/Certification procedure; Benefits of ISO to the organization.

UNIT-IV: Principles of Management: Definition of Management; Administration; Organization; F.W. Taylor's and Henry Fayol's Principles of Management; Functions of Manager; Types of Organization: Line, Staff, Taylor's Pure functional types; Line and staff and committee type; Directing; Leadership; Styles of Leadership; Qualities of a good leader; Motivation; Positive and Negative Motivation; Modern Management Techniques; Just In Time; Total Quality Management (TQM); Quality circle; Zero defect concept; 5S Concept; Management Information Systems. **Personnel Management:** Responsibility of Human Resource Management; Selection Procedure; Training of Workers; Apprentice Training; On the Job training and Vestibule School Training; Job Evaluation and Merit Rating; Objectives and Importance; Wages and Salary Administration; Components of Wages; Wage Fixation; Type of Wage Payment: Halsey's 50% Plan, Rowan's Plan and Emerson's efficiency plan; Numerial Problems.

UNIT-V: Financial Management: Fixed and Working Capital; Resources of Capital; Shares Preference and Equity Shares; Debentures; Type of debentures; Public Deposits; Factory Costing: Direct Cost; Indirect Cost; Factory Overhead; Selling Price of a product; Profit; Numerical Problems; Depreciation; Causes; Methods: Straight line, sinking fund and percentage on Diminishing Value Method; Numerical Problems.

Material Management: Objectives of good stock control system; ABC analysis of Inventory; Procurement and Consumption cycle; Minimum Stock, Lead Time, Reorder Level-Economic Order Quantity problems; Supply Chain.

Reference Books:

1. Industrial Engineering & Management, S.C. Sharma, Khanna Book Publishing Co. (P) Ltd., Delhi
2. Industrial Engineering and Management, O.P. Khanna, Revised Edition, Dhanpat Rai Publications (P) Ltd., New Delhi – 110002.
3. Management, A global perspective, Heinz Weihrich, Harold Koontz, 10th Edition, McGraw Hill International Edition 1994.
4. Essentials of Management, 4th Edition, Joseph L.Massie, Prentice-Hall of India, New Delhi 2004.
5. Principles and Practices of Management, Premvir Kapoor, Khanna Publishing House, N. Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Explain the different types of layout and plant maintenance with safety
CO2	List and explain the need of method study and work measurements
CO3	Explain the production planning and quality control, and its functions
CO4	Understand the basic principles, approaches and functions of management and identify concepts to specific situations
CO5	List and explain the different financial sources and methods of inventory management

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Course Code	:	MEPC307
Course Title	:	CAD/CAM LAB
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Prerequisites	:	Computer Aided Machine Drawing (MEPC104)
Course Category	:	PC

Course Objectives:

- To understand the fundamentals and use CAD.
- To conceptualize drafting and modeling in CAD.
- To interpret the various features in the menu of solid modeling package.
- To synthesize various parts or components in an assembly.
- To prepare CNC programmes for various jobs.

Course Content:

S.No.	Topics for practice
PART-A	**Introduction:** Part modelling; Datum Plane; constraint; sketch; dimensioning; extrude; revolve; sweep; blend; protrusion; extrusion; rib; shell; hole; round; chamfer; copy; mirror; assembly; align; orient.
	Exercises: 3D Drawings of 1). Geneva Wheel; 2). Bearing Block; 3). Bushed bearing: 4). Gib and Cotter joint; 5). Screw Jack; 6). Connecting Rod: Note: Print the orthographic view and sectional view from the above assembled 3D drawing.
PART-B	**CNC Programming and Machining:** Introduction; 1). Study of CNC lathe, milling; 2). Study of international standard codes: G-Codes and M-Codes; 3). Format – Dimensioning methods; 4). Program writing – Turning simulator – Milling simulator, IS practice – commands menus; 5). Editing the program in the CNC machines; 6). Execute the program in the CNC machines; Exercises: Note: Print the Program from the Simulation Software and make the Component in the CNC Machine.
	CNC Turning Machine: (Material: Aluminium/Acrylic/Plastic rod) 1. Using Linear and Circular interpolation - Create a part program and produce component in the Machine. 2. Using Stock removal cycle – Create a part program for multiple turning operations and produce component in the Machine. 3. Using canned cycle - Create a part program for thread cutting, grooving and produce component in the Machine.
	CNC Milling Machine (Material: Aluminium/ Acrylic/ Plastic) 1. Using Linear interpolation and Circular interpolation – Create a part program for grooving and produce component in the Machine. 2. Using canned cycle - Create a part program for drilling, tapping, counter sinking and produce component in the Machine. 3. Using subprogram - Create a part program for mirroring and produce component in the Machine.

Reference Books:

1. Machine Drawing – P.S. Gill S. K. Kataria & Sons, Delhi., 17th Revised edition, 2001
2. Mechanical Draughtsmanship - G.L. Tamta Dhanpat Rai & Sons, Delhi, 1992
3. Inside AutoCAD – D. Raker and H. Rice, BPB Publications, New Delhi, 1985
4. CAD/CAM/CIM – P. Radhakrishnan, S. Subramaniyan & V. Raju, New Age International Pvt. Ltd., New Delhi, 3rd Edition,
5. Engineering AutoCAD, A.P. Gautam & Pradeep Jain, Khanna Book Publishing Co., Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Explain the 3D commands and features of a CAD software
CO2	Create 3D solid model and find the mass properties of simples solids
CO3	Demonstrate the working of CNC turning and milling machine
CO4	Develop the part program using simulation software for Lathe and Milling
CO5	Assess the part program, edit and execute in CNC turning and machining centre

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Course Code	:	MEPC309
Course Title	:	MANUFACTURING ENGINEERING LAB-II
Number of Credits	:	1 (L: 0, T: 0, P: 2)
Prerequisites	:	Manufacturing Engineering (MEPC205)
Course Category	:	PC

Course Objectives:

- To Know the working of Drilling machine, shaper, slotter, planer, milling and grinding machines and be in a position to operate the same.
- To make use of various measuring instruments for taking dimensions.
- To Practice different operations on drilling shaper, slotter, planer, milling and grinding machines.

Course Content:

S.No.	Topics for practice
I	Drilling Exercise (Three different sized holes for different materials maintaining uniform distance between them)
II	Milling-square-hexagon from round bars with indexing and without indexing
III	Generation of spur gear teeth on a round bar
IV	Simple planning exercise cutting 'T' slots (one model)
V	Shaping a Hexagon on a round bar, key ways, grooves splines
VI	Shaping step block cut dovetail to angles 60, 90, 120 degrees
VII	Cylindrical grinding of external surface and internal surface using universal grinding machines
VIII	Grinding Cutting tools to the required angles
IX	Grinding of milling cutters etc, on a tool and cutter grinder

X	Grinding flat surface on a surface grinder using magnetic chuck and clamping devices
XI	Dismantling some of the components of drilling machine and service, assemble the same
XII	Dismantling some of the components of shaper head and then assemble the same
XIII	Dismantling some of the components of Milling machines and service, assemble the same
XIV	Servicing of universal grinding machine

Reference Books:

1. Elements of Workshop Technology (Volume I & II) – Hajra Chowdry & Bhattacharaya, Media Promoters, 11th Edition, 2007
2. Introduction of Basic Manufacturing Processes and Workshop Technology – Rajendersingh, New age International (P) Ltd. NewDelhi, 2006
3. Production Technology – HMT, 18th edition, Tata McGraw Hill, New Delhi
4. Manufacturing process – Myro N Begman, 5 th edition, Tata McGraw Hill, New Delhi

Course outcomes:

At the end of the course, the student will be able to:

CO1	Dismantle and assemble the components on drilling, shaping, milling and grinding machines.
CO2	Perform operations on drilling, shaping, milling and grinding machines.
CO3	Produce articles of industrial application such as Spur gear, square headed bolt, V- block
CO4	Make use of various measuring instruments for taking dimensions

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SEMESTER VI

Course Code	:	MEPC302
Course Title	:	Design of Machine Elements
Number of Credits	:	3 (L: 2, T: 1, P: 0)
Prerequisites	:	Engineering Mechanics (ESC201) Strength of Materials (MEPC204) Theory of Machines & Mechanisms (MEPC206)
Course Category	:	PC

Course Objectives:

- To enable the student to design and draw simple machine components used in small and medium scale industries.
- To understand the basic philosophy and fundamentals of Machine Design.
- To understand the modes of failures of m/c components and decide the design criteria and equations.
- To analyze and evaluate the loads, forces, stresses involved in components and subassemblies and decide the dimensions.
- To develop analytical abilities to give solutions to engineering design problems.

Course Content:

UNIT-I: Introduction to Design: Machine Design philosophy and Procedures; General Considerations in Machine Design; Fundamentals: Types of loads, concepts of stress, Strain, Stress – Strain Diagram for Ductile and Brittle Materials, Types of Stresses; Bearing pressure Intensity; Crushing; Bending and Torsion; Principal Stresses; Simple Numericals; Creep strain and Creep Curve; Fatigue; S-N curve; Endurance Limit; Factor of Safety and Factors governing selection of factor of Safety; Stress Concentration: Causes & Remedies; Converting actual load or torque into design load or torque using design factors like velocity factor, factor of safety & service factor; Properties of Engineering materials; Designation of materials as per IS and introduction to International standards & advantages of standardization; Use of design data book; Use of standards in design and preferred numbers series; Theories of Elastic Failures; Principal normal stress theory; Maximum shear stress theory & Maximum distortion energy theory.

UNIT-II: Design of simple machine parts: Cotter Joint; Knuckle Joint; Turnbuckle; Design of Levers: Hand/Foot Lever & Bell Crank Lever; Design of C–Clamp; Off-set links; Overhang Crank; Arm of Pulley.

Antifriction Bearings: Classification of Bearings; Sliding contact & Rolling contact; Terminology of Ball bearings: Life Load relationship, Basic static load rating and Basic dynamic load rating, limiting speed; Selection of ball bearings using manufacturer's catalogue.

UNIT-III: Design of Shafts, Keys, Couplings and Spur Gears: Types of Shafts; Shaft materials; Standard Sizes; Design of Shafts (Hollow and Solid) using strength and rigidity criteria; ASME code of design for line shafts supported between bearings with one or two pulleys in between or one overhung pulley; Design of Sunk Keys; Effect of Keyways on strength of shaft; Design of Couplings – Muff Coupling, Protected type Flange Coupling, Bush-pin type flexible coupling; Spur gear design considerations; Lewis equation for static beam strength of spur gear teeth; Power transmission capacity of spur gears in bending.

UNIT-IV: Design of Power Screws: Thread Profiles used for power Screws - Relative merits and demerits of each; Torque required to overcome thread friction; Self-locking and overhauling property;

Efficiency of power screws; Types of stresses induced; Design of Screw Jack; Toggle Jack.

Design of springs: Classification and Applications of Springs; Spring terminology; Materials and Specifications; Stresses in springs; Wahl's correction factor; Deflection of springs; Energy stored in springs; Design of Helical, Tension and Compression springs subjected to uniform applied loads like I.C. engine valves, Weighing balance, Railway buffers and Governor springs; Leaf springs: Construction and Application.

UNIT-V: Design of Fasteners: Stresses in Screwed fasteners; Bolts of Uniform Strength; Design of Bolted Joints subjected to eccentric loading; Design of Parallel and Transverse fillet welds; Axially loaded symmetrical section; Merits and demerits of screwed and welded joints.

Ergonomics & Aesthetic consideration in design: Ergonomics of Design: Man–Machine relationship; Design of Equipment for control, environment & safety; Aesthetic considerations regarding shape, size, color & surface finish.

Reference Books:

1. Machine Design – Sadhu Singh, Khanna Book Publishing Co., Delhi (ISBN: 978-9382609-575)
2. Machine Design Data Book – Sadhu Singh, Revised Edition, Khanna Book Publishing Co., Delhi (ISBN: 978-9382609-513)
3. Introduction to Machine Design – V.B.Bhandari, Tata Mc- Graw Hill, New Delhi.
4. Mechanical Engineering Design – Joseph Edward Shigley, Tata Mc- Graw Hill, New Delhi.
5. Machine design – Pandya & Shah, Dhanpat Rai & Son, New Delhi.
6. Machine design – R.K.Jain, Khanna Publication, New Delhi.
7. Design Data Book – PSG Coimbtore, PSG Coimbtore.
8. Hand Book of Properties of Engineering Materials & Design Data for Machine Elements – Abdulla Shariff, Dhanpat Rai & Sons, New Delhi.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Analyze the various modes of failure of machine components under different load patterns.
CO2	Design and prepare part and assembly drawings.
CO3	Use design data books and different codes of design.
CO4	Select standard components with their specifications from manufacturer's catalogue.
CO5	Develop drawings on CAD software.

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Course Code	:	MEPC304
Course Title	:	PRODUCTION & OPERATIONS MANAGEMENT
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- One of the most critical areas for success in any business enterprise is how Production and Operations are managed.
- To study the statistics, economics, finance, organizational behaviour and strategy into a consolidated production and operation related decisions.
- To discuss the role of location strategy and the criteria for location decisions.
- To define quality and explain quality management, including TQM and its tools.

Course Content:

UNIT-I: Process Planning and Process Engineering: Process Planning: Introduction, Function, Pre-requisites and steps in process planning, Factors affecting process planning, Make or buy decision, plant capacity and machine capacity. Process Engineering: Preliminary Part Print Analysis: Introduction, Establishing the General Characteristics of work piece, determining the principal Process, Functional surfaces of the work piece, Nature of the work to be Performed, Finishing and identifying operations. Dimensional Analysis: Introduction, types of dimensions, measuring the Geometry of form, Baselines, Direction of specific dimensions. Tolerance Analysis: Causes of work piece variation, Terms used in work piece dimensions, Tolerance stacks. Work piece Control: Introduction, Equilibrium Theories, Concept of location, Geometric Control, Dimensional control, Mechanical control.

UNIT-II: Production Forecasting: Introduction of production forecasting, The strategic role of forecasting in supply chain, Time frame, Demand behavior, Forecasting methods- Qualitative and Quantitative, Forecast accuracy.

Scheduling:

Introduction, Objectives in scheduling, Loading, Sequencing, Monitoring, Advanced Planning and Scheduling Systems, Theory of Constraints, Employee scheduling.

UNIT-III: Break-Even Analysis: Introduction, Break-even analysis charts, Breakeven analysis for process, plant and equipment selection.

Aggregate Operations Planning: Aggregate production planning, Adjusting capacity to meet the demand, Demand management, Hierarchical and collaborative planning, Aggregate planning for services.

UNIT-IV: Assembly Line Balancing: Assembly lines, Assembly line balancing, Splitting tasks, Flexible and U-shaped line layouts, Mixed model line balancing, Current thoughts on assembly lines, Computerized assembly line balancing.

UNIT-V: Material Management: Introduction, Importance and objectives, Purchasing and Stores: policies and procedures, Vendor development, selection, analysis and rating.

Reference Books:

1. Production and Operations Management – K.Aswathappa, K.Shridhara Bhat, Himalaya Publishing House, 2014.
2. Production and Operations Management – Shailendra Kale, McGraw Hill Educations(India) Private Limited,2013.
3. Production and Operations Management – R.Paneerselvam, PHI Learning Private Limited, 2013.

4. Operations Management – Joseph Monk, TMH Publishers, New Delhi, 2004.
5. Modern Production /Operations Management – Buffa Elwood S, John Wiley Publishers, Singapore, 2002.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Define operations management and explain its relationship to productivity. And also understand tools and techniques.
CO2	Describe the importance of forecasting and explain the effective application of the different forecasting approaches and methods.
CO3	Explain layout strategy and how operations managers determine facility arrangements and size.
CO4	Describe how operations managers achieve a reasonable work environment and set expectations related to employee productivity.
CO5	Understand make-or-buy decisions, and the selection and integration of suppliers. And how much to order and when to order.

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Course Code	:	MEPE###
Course Title	:	TOOL ENGINEERING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Objectives:

- To understand metal cutting and forming process and factors affecting machinability.
- To develop knowledge of tools, dies and tool materials.
- To understand processes for increased productivity and quality.

Course Content:

UNIT-I: Metal Cutting: Mechanics of Metal cutting; requirements of tools; cutting forces; types of chips; chip thickness ratio; shear angle ; simple numericals only; types of metal cutting process; orthogonal; oblique and form cutting;

Cutting fluids: types; characteristics and applications.

Tool wear: Types of wear; Tool life; Tool life equations.

Unit-II: Machinability: definition; factors affecting machinability; machinability index.

Tool materials: Types; characteristics; applications; Heat treatment of tool steels; Specification of carbide tips; Types of ceramic coatings.

Cutting Tool Geometry: Single point cutting tool; drills; reamers; milling; cutters.

Unit-III: Types of dies and construction: Simple Die; Compound Die; Progressive Die; Combination Die.

Punch & Die mountings: pilots; strippers; misfeed detectors; Pressure Pads; Knock outs; stock guide; Feed-Stop; guide bush; guide pins.

Unit-IV: Die Design Fundamentals: Die Operations; blanking; piercing; shearing; cropping; notch-

ing; lancing; coining; embossing; stamping; curling; drawing; bending; forming; Die set; Die shoe; Die area; Calculation of clearances on die and punch for blanking and piercing dies; Strip layout; Calculation of material utilization factor.

Unit-V: Forming Dies: Bending methods; Bending Dies; bend allowance; spring back; spanking; bending pressure; pressure pads; development of blank length.

Drawing: operations; Metal flow during drawing; Calculation of Drawing blank size; variables affecting metal flow during drawing; single action and double action dies; combination dies.

Fundamentals of other Tools: Constructional features of - Pressure Die casting dies; metal extrusion dies; injection molding dies; forging dies; plastic extrusion dies.

Reference Books:

1. Tool Design - Donaldson Anglin, Tata McGraw Hill.
2. Production Technology- H.M.T.Jain, Tata McGraw Hill.
3. A Text Book of Production engineering – P.C. Sharma, S.Chand & Co.
4. Production Technology, R.K.Jain, Khanna Publishers.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand concepts, principles and procedures of tool engineering
CO2	Classify and explain various tools and tool operations
CO3	Select proper tool and a die for a given manufacturing operation to achieve highest productivity
CO4	Estimate tool wear and tool life

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Course Code	:	MEPE###
Course Title	:	COMPUTER INTEGRATED MANUFACTURING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Objectives:

- To understand General Principles of Mechanical Engineering.
- To understand laws of thermodynamics, thermal and thermodynamic Processes
- To understand working principles of power developing and power absorbing devices
- To understand basic materials and manufacturing processes

Course Content:

UNIT-I: Concept of Computer Integrated Manufacturing (CIM); Basic components of CIM; Distributed database system; distributed communication system, computer networks for manufacturing; future automated factory; social and economic factors

Unit-II: Computer Aided Design (CAD): CAD hardware and software; product modelling, automatic

drafting; engineering analysis; FEM design review and evaluation; Group Technology Centre.

Unit-III: Computer Aided Manufacturing (CAM), Computer assisted NC part programming; Computer assisted robot programming; computer aided process planning (CAPP); computer aided material requirements planning (MRP)

Unit-IV: Computer aided production scheduling; computer aided inspection planning; computer aided inventory planning, Flexible manufacturing system (FMS); concept of flexible manufacturing.

Unit-V: Integrating NC machines, robots, AGVs, and other NC equipment; Computer aided quality control; business functions, computer aided forecasting; office automation

Reference Books:

1. CAD, CAM, CIM - P.Radhakrishnan and S.Subramanyan, New Age International Publishers.

2. Computer Integrated Manufacturing - Paul G. Rankey, Prentice Hall.

3. Robotics Technology and Flexible Automation – S.R. Deb, Tata McGraw Hill.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand the formulation of Liner Programming
CO2	Analyze and Convert the problem into a mathematical model.
CO3	Understand the dual LP and Primal Dual relation problems
CO4	Understand and implement the transportation problems at workplace
CO5	Solve the assignment problems, solving linear programming approach using software

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Course Code	:	MEPE###
Course Title	:	COMPUTER AIDED DESIGN AND MANUFACTURING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Computer Aided Machine Drawing Practice (MEPC104)
Course Category	:	PE

Course Objectives: To provide an overview of how computers are being used in design, development of manufacturing plans and manufacture.

- To understand concepts of drafting and modelling using CAD.
- To understand the need for integration of CAD and CAM.
- To understand the concepts of flexible manufacturing system.

Course Content:

UNIT-I: Fundamentals of CAD/CAM: Automation; Design process; Application of computers for design; Benefits of CAD; Computer configuration for CAD applications; Design workstation; Graphic terminal; CAD Software: Definition of system software and application software; CAD database and structure.

Geometric Modeling: 3D-Wire frame modeling; Wire frame entities and their definitions; Interpolation and Approximation of curves; Concept of Parametric and Non-parametric representation of curves; Curve fitting techniques.

Unit-II: Surface Modeling: Algebraic and Geometric form; Parametric space of surface; Blending functions; Parametrization of surface patch; Subdividing; Cylindrical surface; Ruled surface; Surface of revolution; Spherical surface; Composite surface; Bezier surface; Solid Modelling: Definition of cell composition and spatial occupancy enumeration; Sweep representation; Constructive solid geometry; Boundary representations.

Unit-III: NC Control Production Systems: Numerical control; Elements of NC system; NC part programming; Methods of NC part programming; Manual part programming, Computer assisted part programming; Post processor; Computerized part program.

Unit-IV: Group Technology: Part families; Parts classification and coding; Production analysis; Machine cell design; Computer aided process planning: Retrieval type and Generative type; Machinability data systems; MRP and its Benefits.

Unit-V: Flexible manufacturing system: F.M.S equipment; Layouts; Analysis methods and benefits; Computer aided quality control; Automated inspection: Off-line, On-line, Contact, Non-contact; Coordinate measuring machines; Machine vision; CIM system and Benefits.

Reference Books:

1. CAD/CAM Principles and Applications, P.N.Rao, Tata McGraw-Hill
2. Computer Aided Design and Manufacturing, Groover M.P. & Zimmers Jr, Prentice hall of India
3. CAD/CAM/CIM, RadhaKrishna P. & Subramanyam, Wiley Eastern Ltd

Course outcomes:

At the end of the course, the student will be able to:

CO1	Develop mathematical models to represent curves and surfaces and Model engineering components using solid modeling techniques.
CO2	Understand geometric transformation techniques in CAD.
CO3	Develop programs for CNC to manufacture industrial components.
CO4	Understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.
CO5	Utilize Flexible manufacturing system tools.

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Course Code	:	MEPE###
Course Title	:	INDUSTRIAL ROBOTICS & AUTOMATION
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites (Course code)	:	NIL
Course Category	:	PE

Course Objectives:

- To introduce the basic concepts, parts of robots and types of robots.
- To make the student familiar with the various drive systems for robot, sensors and their applications in robots and programming of robots.
- To select the robots according to its usage.

- To discuss about the various applications of robots, justification and implementation of robot.
- To Conceptualize automation and understand applications of robots in various industries.

Course Content:

UNIT-I: Fundamentals of Robotics: Introduction; Definition; Robot anatomy (parts) and its working; Robot Components: Manipulator, End effectors; Construction of links, Types of joints; Classification of robots; Cartesian, Cylindrical, Spherical, Scara, Vertical articulated; Structural Characteristics of robots; Mechanical rigidity; Effects of structure on control work envelope and work Volume; Robot work Volumes, comparison; Advantages and disadvantages of robots.

Unit-II: Robotic Drive System and Controller: Actuators; Hydraulic, Pneumatic and Electrical drives; Linear actuator; Rotary drives; AC servo motor; DC servo motors and Stepper motors; Conversion between linear and rotary motion; Feedback devices; Potentiometers; Optical encoders; DC tachometers; Robot controller; Level of Controller; Open loop and Closed loop controller; Microprocessor based control system; Robot path control: Point to point, Continuous path control and Sensor based path control; Controller programming.

Unit-III: Sensors: Requirements of a sensor; Principles and Applications of the following types of sensors: Position sensors (Encoders, Resolvers, Piezo Electric); Range sensors (Triangulation Principle, Structured lighting approach); Proximity sensing; Force and torque sensing.

Introduction to Machine Vision: Robot vision system (scanning and digitizing image data); Image processing and analysis; Cameras (Acquisition of images); Videocon camera (Working principle & construction); Applications of Robot vision system: Inspection, Identification, Navigation & serving.

Unit-IV: Robot kinematics and Robot Programming: Forward Kinematics; Inverse Kinematics and Differences; Forward Kinematics and Reverse Kinematics of Manipulators with Two Degrees of Freedom (In 2 Dimensional); Deviations and Problems. Teach Pendant Programming; Lead through programming; Robot programming Languages; VAL Programming; Motion Commands; Sensor Commands; End effecter commands; and Simple programs

Unit-V: Automation: Basic elements of automated system, advanced automation functions, levels of automation.

Industrial Applications: Application of robots in machining; welding; assembly and material handling.

Reference Books:

1. Introduction to Robotics: Analysis, Systems, Applications – Saeed B. Niku, Pearson Education Inc. New Delhi 2006.
2. Industrial Robotics: Technology, Programming and Applications – M.P. Groover, Tata McGraw Hill Co, 2001.
3. Robotics Control, Sensing, Vision and Intelligence – Fu.K.S. Gonzalz.R.C and Lee C.S.G, McGraw Hill Book Co, 1987.
4. Robotics for Engineers – Yoram Koren, McGraw Hill Book Co, 1992.
5. A Text book on Industrial Robotics – Ganesh S. Hedge, Laxmi Publications Pvt. Ltd., New Delhi, 2008.
6. Robotics Technology and Flexible Automation – S.R. Deb & Sankha Deb, Tata McGraw-Hill, 2010.
7. Elements of Robotics Process Automation, Mukherjee, Khanna Publishing House, Delhi, 2018

Course outcomes:

At the end of the course, the student will be able to:

CO1	Explain the robot anatomy, classification, characteristics of robot, advantages and disadvantages.
CO2	Explain the various robotic actuators on hydraulic, pneumatic and electrical drives.
CO3	Explain about various types of sensors and concepts on robot vision system.
CO4	Explain the concepts of robot programming languages and various methods of robot programming.
CO5	Explain the various applications of robots.

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Course Code	:	MEPE###
Course Title	:	HEAT TRANSFER
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Basic Mechanical Engineering (MEPC102)
Course Category	:	PE

Course Objectives:

- To understand the concepts of conduction.
- To understand the concepts of Fins heat transfer.
- To understand the concepts of radiation.
- To understand the concepts of convection.
- To understand the basics of heat exchangers.

Course Content:

UNIT-I: Conduction: Fourier law of heat conduction for isotropic material; Thermal conductivity; Derivation of the energy equation in three dimensions including transient effect; Nondimensional - thermal diffusivity and Fourier number; Types of boundary conditions (Dirchlet, Neumann, mixed type); One dimensional solution with and without heat generation; Analogy with electrical circuits.

Unit-II: Fins: rectangular and pin fins. Fin effectiveness and efficiency. Critical thickness of insulation. Lumped parameter approach and physical significance of time constant, Biot number, Validity of lumped parameter approach. Introduction to Heissler Chart.

Unit-III: Convection: Introduction, Newton's law of cooling; Momentum and energy equations in two dimensions; nondiemnsionalisation, importance of nondimensional quantities and their physical significance. Velocity and thermal boundary layer thickness by integral method. Analogies between momentum, heat and mass transfer. Natural convection, effect of coupling on the conservation equations.

Unit-IV: Radiation : Physical mechanism of thermal radiation, laws of radiation, dfeinition of black body, emissive power, intensity of radiation, emissivity, reflectivity, transmittivity, irradiation, radiosity. Radiation exchange between black bodies, concept of Gray-Diffuse Isotropic (GDI) surface. Radiation exchange between GDI surfaces by radiation network and radiosity matrix method. Radiation shielding.

Unit-V: Heat exchangers: Types of heat exchangers, parallel and counterflow types, Introduction to LMTD. Correction factors, fouling factor. NTU method for heat exchangers.

Reference Books:

1. Fundamentals of Heat and Mass Transfer by F.P.Incropera and D.P.Dewitt, 4th ed., John Wiley & Sons.
2. Heat Transfer - A Basic Approach by M.N.Ozisik, McGrawhill.
3. Heat Transfer by J.P.Holman, 8th ed., McGrawhill.
4. Elements of Heat & Mass Transfer by Vijay Gupta, 2nd ed., New Age International Publishers.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand the concepts of conduction
CO2	understand the concepts of fins
CO3	Understand the concepts of radiation.
CO4	Understand the concepts of convection
CO5	Understand the basic concepts of heat exchangers.

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Course Code	:	MEPE###
Course Title	:	REFRIGERATION AND AIR-CONDITIONING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Thermal Engineering - I (MEPC202)
Course Category	:	PE

Course Objectives:

- To understand the basics of Refrigeration cycles.
- To understand basics of vapour compression and vapour absorbtion systems.
- To identify components and refrigerants and lubricants of a refrigeration system.
- To understand control strategies for refrigeration system.
- To understand the basics about air conditioning systems.

Course Content:

UNIT-I: Introduction to Refrigeration: Definition of Refrigeration; Refrigerating effect-unit of refrigeration- Coefficient of performance; Types of Refrigeration-Ice, dry ice, Steam jet, Throttling, Liquid nitrogen refrigeration; Carnot refrigeration Cycle; Air refrigeration- Bell - Coleman cycle, PV& TS diagram; Advantage and disadvantages in air refrigeration; Simple problems

Unit-II: Refrigeration systems: Basic Components, Flow diagram of working of Vapour compression cycle; Representation of the vapour compression cycle on P-H, T-S & P-V Diagram; Expression for Refrigerating effect, work done and power required; Types of Vapour Compression cycle; Effects of super heating and under cooling, its advantages and disadvantages; Simple Vapour absorptions cycle and its flow diagram; Simple Electrolux system for domestic units; Comparison of Vapour absorption and vapour compression system; Simple problems on vapour compression cycle.

Unit-III: Refrigeration equipments: Compressor - types of compressors; Hermetically sealed and Semi hermetically sealed compressor; Condensers - Air Cooled, water cooled, natural and forced draught cooling system; Advantages and disadvantages of air cooled and water cooled condensers; Evaporators -natural, convection, forced convection types.

Refrigerants and lubricants: Introduction to refrigerants; Properties of good refrigerants; Classification of refrigerants by group number and commonly used refrigerants in practice; Detection of refrigerants leakage; Charging the system with refrigerant; Lubricants used in refrigeration and their properties.

Unit-IV: Refrigerant flow controls: Capillary tube; Automatic Expansion valve; Thermo static expansion valve; High side and low side float valve; Solenoid valve; Evaporator pressure regulator.

Application of refrigeration: Slow and quick freezing; Cold storage and Frozen storage; Dairy refrigeration; Ice making industry; Water coolers.

Unit-V: Air conditioning: Introduction to Air conditioning; Factors affecting Air conditioning; Psychometric chart and its use; Psychometric process-sensible heating and cooling, Humidifying and dehumidifying; Adiabatic saturation process; Equipments used in air conditioning cycle; Air conditioning units and plants.

Refrigeration and Air-conditioning tools: Tools used in refrigeration and Air conditioner installation; Installation procedure; Faults in refrigeration and air conditioning system; Servicing procedure.

Reference Books:

1. Refrigeration and Air Conditioning – Sadhu Singh, Khanna Book Publishing Co., New Delhi
2. Refrigeration and Air Conditioning – S. Domakundawar, Dhanpat Rai publications.
3. Refrigeration and Air Conditioning – A.S.Sarao & G.S. Gabi, 6th edition, Satya Prakashan publications, New Delhi, 2004.
4. Principles of Refrigeration – Roy J.Dossat, 5th edition, Pearson Publications, 2001.
5. Refrigeration and Air Conditioning – M.Zakria Baig, Premier/ Radiant Publishing House.
6. Refrigeration and Air Conditioning – C.P Arora, Tata McGraw Hill Education, 2000.

Course outcomes

At the end of the course, the student will be able to:

CO1	Define refrigeration and types of Refrigeration cycles
CO2	Explain Vapour Compression and Vapour Absorbtion System working principles
CO3	Identify the components required for refrigeration system.
CO4	Identify the controlling components for a refrigeration system.
CO5	Explain the working principles of Air-conditioning.

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Course Code	:	MEPE###
Course Title	:	AUTOMOBILE ENGINEERING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Objectives:

- To understand the basic structure and components of an automobile.
- To understand the concepts of cooling and lubricating systems.
- To understand the concepts of Ignition and transmission and steering systems.
- To understand the classification and necessity of suspension system.
- To identify different special vehicles.

Course Content:

UNIT-I: Introduction to basic structure of an automobile: Basic engine components; Cylinder block; Cylinder head; Gaskets; cylinder liners, types of cylinder liners; Piston and piston pin; piston rings, types of piston rings; Connecting rod; Crank shaft; Cam shaft; Crankcase; Engine valves; Fly-wheel and Governer.

Unit-II: Cooling and lubrication system: The necessity of cooling system; Types of cooling system-air cooling and water cooling; Air cooling system; Types of water cooling system –Thermosyphon system and pump circulation system; Advantages and disadvantages of air cooling and water cooling systems; The components of water cooling system –fan, radiator, pump and thermostat; The necessity of lubrication system; S.A.E rating of lubrication system; Types of lubrication system; Petrol lubrication and high pressure lubrication system.

Fuel feed system: Conventional fuels and alternative fuels: Cetane and octane numbers; Types of carburettors; Working of simple carburettor; Multi point and single point fuel injection systems; Different fuel transfer pumps; Working of S.U electrical and A.C mechanical pump; Fuel filters; Fuel injection pump; Fuel injectors.

Unit-III: Ignition system: Introduction to ignition system; Battery Ignition systems and magneto Ignition system; Electronic Ignition system; Construction and working of lead acid battery; Elements of charging system; Elements of starting system; Types of lights used in the automobile:

Transmission and steering system: General arrangement of clutch; Principle of friction clutches; Constructional details of Single plate clutch; Constructional details of multi-plate clutch; Constructional details of centrifugal clutch; Necessity for gear ratios in transmission; Types of gear boxes; Working of sliding mesh gear box; Working of constant mesh gear box; Working of propeller shaft Working of propeller shaft; Working of universal joint; Working of differential; Types of rear axle; Purpose of front axle; Necessity of steering system; Caster, camber and king pin inclination; Rack and pinion steering system; Power steering.

Unit-IV: Suspension system: Necessity of suspension system; Torsion bar suspension systems; Leaf spring and coil spring suspension system; Independent suspension for front wheel and rear wheel; Working of telescopic shock absorber; Functions of brakes; Types of brakes; Working of internal expanding brake; Working of disc brake

Unit-V: Special vehicles: Introduction to Special vehicles; Tractor; Motor grader; Scrappers; Excavators; Duper trucks.

Reference Books:

1. Automobile Engineering Vol I, II, Kirpal Singh, Standard Publishers Distributors, Delhi. 2012.
2. Automobile Mechanics, A.K. Babu, S.C. Sharma, Khanna Publications, New Delhi
3. Automotive Mechanics: Principles and Practices, Joseph Heitner, East West Press
4. Automotive Mechanics, S. Srinivasan, 2nd Edition, Tata McGraw Hill
5. Automobile Engineering Vol I and Vol II, K. M. Gupta, Umesh Publications.
6. Automotive Engineering, Jain and Asthana, Tata McGraw Hill.

Course outcomes

At the end of the course, the student will be able to:

CO1	Identify the components of an automobile with their working
CO2	Explain the concepts of cooling and lubricating systems.
CO3	Explain the concepts of Ignition and Transmission and steering systems.
CO4	Identify different suspension systems and their applications.
CO5	Differentiate the special vehicles according to the usage.

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Course Code	:	MEPE###
Course Title	:	POWER PLANT ENGINEERING
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	Thermal Engineering - I (MEPC202)
Course Category	:	PE

Course Objectives:

- To understand the present scenario of power in India.
- To recognize various load terminologies used in power plants.
- To understand hydro working principles
- To understand working of Diesel, Gas and Nuclear power plants.
- To understand the issues and safety precautions in power plants.

Course Content:

UNIT-I: Introduction to Power plant: Introduction to power plant; Indian Energy scenario in India; Location of power plant; Choice of Power plant; Classification of power plants.

Unit-II: Economics of power plant: Terminology used in power plant: Peak load, Base load, Load factor, Load curve; Various factor affecting the operation of power plant; Methods of meeting the fluctuating load in power plant; Load sharing- cost of power-tariff methods; Performance and operating characteristics of power plant.

Unit-III: Hydro power plant: Introduction to Hydro electric power plant; Rainfall, Runoff and its measurement, Hydrograph, flow duration curve; Selection of sites for hydro electric power plant; General layout of Hydro electric power plant and its working; Classification of the Plant-Run off river plant, storage river plant, pumped storage plant; Advantages and disadvantages of hydro electric power plant.

Unit-IV: Diesel and Gas turbine plant: The layout of diesel power plant; Components and the working of diesel power plant; Advantages and disadvantages of diesel power plant; Gas turbine power Plant-Schematic diagram, components and its working; Combined cycle power generation- Combined gas and steam turbine power plant operation (only flow diagram).

Nuclear power plant: Introduction; Nuclear Power-Radio activity-Radioactive charge-types of reactions; Working of a nuclear power plant; Thermal fission Reactors- PWR, BWR and gas cooled reactors; Advantages and Disadvantages of Nuclear power plant.

Unit-V: Environmental impact of Power plant: Social and Economical issues of power plant; Green house effect; Acid precipitation-Acid rain, Acid snow, Dry deposition, Acid fog; Air, water, Thermal pollution from power plants; Radiations from nuclear power plant effluents.

Power plant safety: Plant safety concept; Safety policy to be observed in power plants; Safety practices to be observed in boiler operation; Safety in oil handling system; Safety in Chemical handling system; Statutory provision related to boiler operation.

Reference Books:

1. Power plant Engineering-P.K. Nag 4th edition, Tata McGraw Hill Education, 2014.
2. Power plant Engineering – Frederick T. Morse, Litton Educational Publishing Inc. 1953.
3. A Course in Power Plant Engineering – Subhash C. Arora, S. Domakundwar, Dhanpat Rai, 1984.
4. Power Plant Engineering – P.C. Sharma, S.K.Kataria & sons, 2009.
5. Power System Engineering – R.K. Rajput, Firewell Media,2006.

Course outcomes

At the end of the course, the student will be able to:

CO1	Familiarised with the present and future power scenario of India.
CO2	Enlist various load terminologies in power plants
CO3	Working and classifications in hydro power plant
CO4	Working principles of Diesel, Gas and Nuclear power plants.
CO5	Understand the issues and necessity of safety concepts of power plants.

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Course Code	:	MEPE###
Course Title	:	FARM EQUIPMENT AND FARM MACHINERY
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Objectives:

- To find and characterize the machinery based on crop production.
- To find the field efficiency and capacities to calculate the economics of machinery.
- To find the machines usages for different tillage, and its power requirement calculations.
- To understand sowing, planting & transplanting equipment based on crop.
- To understand machinery materials and heat effects for different farm machinery equipment.

Course Content:

UNIT-I: Introduction to farm mechanization. Classification of farm machines. Unit operations in crop production. Identification and selection of machines for various operations on the farm. Hitching systems and controls of farm machinery.

Unit-II: Calculation of field capacities and field efficiency. Calculations for economics of machinery usage, comparison of ownership with hiring of machines. Introduction to seed-bed preparation and its classification. Familiarization with land reclamation and earth moving equipment

Unit-III: Introduction to machines used for primary tillage, secondary tillage, rotary tillage, deep tillage and minimum tillage. Measurement of draft of tillage tools and calculations for power requirement for the tillage machines. Introduction to tillage machines like mould-board plough, disc plough, chisel plough, sub-soiler, harrows, puddler, cultivators, identification of major functional components. Attachments with tillage machinery

Unit-IV: Introduction to sowing, planting & transplanting equipment. Introduction to seed drills, no-till drills, and strip-till drills. Introduction to planters, bed planters and other planting equipment like sugarcane, potato. Study of types of furrow openers and metering systems in drills and planters. Calibration of seed-drills/ planters. Adjustments during operation.

Unit-V: Introduction to materials used in construction of farm machines. Heat treatment processes and their requirement in farm machines. Properties of materials used for critical and functional components of agricultural machines. Introduction to steels and alloys for agricultural application. Identification of heat treatment processes specially for the agricultural machinery components.

Reference Books:

1. Principles of Farm Machinery - R.A. Kepner, Roy Bainer, and E. L. Berger
2. Farm Machinery and Equipment - H. P. Smith
3. Farm Machinery and equipment - C. P. Nakra
4. Engineering principles of Agril. Machines - Dr. Ajit K. Srivastav, Caroll E. Goering and Roger P. Rohrbach.

5. Farm Machinery – an Approach - S. C Jain & Grace Phillips
6. Agril. Engineering through worked out examples - Dr. R. Lal and Dr. A.C. Dutta
7. Farm Power and Machinery Engineering - Dr.R. Suresh and Sanjay Kumar

Course Outcomes:

At the end of the course, the student will be able to:

CO1	Classify the Farm Machineries, equipment and materials
CO2	Describe the objectives of Farm mechanization.
CO3	Explain selection of the machineries
CO4	Discuss the forces acting on tillage tools and hitching systems
CO5	Understand the calibration, constructional features and working of various farm equipment.

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Course Code	:	MEPE###
Course Title	:	MATERIAL HANDLING SYSTEM
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PC

Course Objectives:

- To know the operational features of the material handling equipment & its practical applications.
- To understand, select, operate and maintain the material handling equipments.
- To understand different material handling processes used in industries.
- To understand & appreciate safety instrumentation for equipment.

Course Content:

UNIT-I: Introduction to Material Handling System: Main types of Material handling equipments & their applications; Types of load to be handled; Types of Movements; Methods of stacking, loading & unloading systems; Principles of Material Handling Systems; Modern trends in Materials handling.

UNIT-II: Hoisting Machinery & Equipments: Construction, Working & Maintenance of different types of hoists such as Lever operated hoist, Portable hand chain hoist, Differential hoists, Worm geared and Spur geared hoists, Electric & Pneumatic hoists, Jumper; Construction, Working & Maintenance of different types of cranes such as Rotary cranes, Trackless cranes, Mobile cranes, Bridge cranes, Cable cranes, Floating cranes & Cranes traveling on guide rails; Construction, Working & Maintenance of Elevating equipments such as Stackers, Industrial lifts, Freight elevators, Passenger lifts, and Mast type's elevators, Vertical skip hoist elevators.

UNIT-III: Conveying Machinery: Construction, Working & Maintenance of Traction type conveyors such as Belt conveyors, Chain conveyors, Bucket elevators, Escalators; Construction, Working & Maintenance of Traction less type conveyors such as Gravity type conveyors, Vibrating & Oscillating conveyors, Screw conveyors, Pneumatic & Hydraulic conveyors, Hoppers gates & Feeders.

Surface Transportation Equipment: Construction, Function, Working of Trackless equipment such as Hand operated trucks, Powered trucks, Tractors, Automatic Guided vehicle, Industrial Trailers; Construction, Function, Working of Cross handling equipment such as Winches, Capstans, Turntables, Transfer tables, Monorail conveyors.

UNIT-IV: Components of Material Handling Systems: Flexible hoisting appliances such as Welded load chains, Roller chains, Hemp ropes, Steel wire ropes, Fastening methods of wire & chains, Eye bolts, Lifting tackles, Lifting & Rigging practices; Load handling attachments: a) Various types of hooks-Forged, Triangular eye hooks, Appliances for suspending hooks b) Crane grab for unit & piece loads c) Electric lifting magnet, vacuum lifter. d) Grabbing attachment for loose materials e) Crane attachment for handling liquids/molten metals; Construction & Working of Arresting gear & Brakes; Construction & use of electromagnetic shoe brakes, Thruster operated shoe brakes, Control brakes.

UNIT-V: Mechanism used in Material Handling Equipment: Steady state motion; Starting & stopping of motion in following mechanisms: Hoisting mechanism, Lifting Mechanism, Traveling Mechanism, Slewing Mechanism, Rope & chain operated Cross- Traverse Mechanism.

Selection of Material Handling Equipment: Factors affecting choice of material handling equipment such as Type of loads, Hourly capacity of the unit, Direction & length of travel, Methods of stocking at initial, final & intermediate points, Nature of production process involved, Specific load conditions & Economics of material handling system.

Reference Books:

1. Material handling (Principles & Practice) – Allegri T. H., CBS Publisher, New Delhi.
2. Plant Layout & Materials Handling – Apple J. M., JohnWiley Publishers.
3. Material Handling Equipment – N. Rundenko, Peace Publisher, Moscow.
4. Material Handling Equipment – M. P. Alexandrov, MIR Publisher, Moscow.
5. Material Handling Equipment – Y. I. Oberman, MIR Publisher, Moscow.

Course outcomes

At the end of the course, the student will be able to:

CO1	Understand constructional & operational features of various materials handling systems.
CO2	Identify, compare & select proper material handling equipment for specified applications.
CO3	Know the controls & safety measures incorporated on material handling equipment.
CO4	Appreciate the role of material handling devices in mechanization & automation of industrial process.
CO5	Understand & appreciate safety instrumentation for equipment

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Course Code	:	MEPE###
Course Title	:	HYBRID VEHICLES
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites	:	NIL
Course Category	:	PE

Course Objectives:

- To understand the basics of electric vehicle history and components.
- To understand properties of batteries.
- To understand the electrical machine properties and classifications.
- To understand the properties of electric vehicle drive systems
- To understand the concepts of hybrid electric vehicles.

Course Content:

UNIT-I: Electric Vehicles: Introduction; History of Hybrid and Electric Vehicles; Social and Environmental importance of Hybrid and Electric Vehicles; Components, Vehicle mechanics: Roadway fundamentals, Vehicle kinetics, Dynamics of vehicle motion; Propulsion System Design.

Unit-II: Battery: Basics; Types; Parameters: Capacity, Discharge rate, State of charge, State of Discharge, Depth of Discharge; Technical characteristics, Battery pack Design, Properties of Batteries.

Unit-III: DC & AC Electrical Machines: Motor and Engine rating; Requirements; DC machines; Three phase A/c machines; Induction machines; Permanent magnet machines; Switched reluctance machines.

Unit-IV: Electric Vehicle Drive Train: Transmission configuration; Components: Gears, Differential, Clutch, Brakes; Regenerative braking, Motor sizing; Fuel efficiency analysis.

Unit-V: Hybrid Electric Vehicles: Types: Parallel, Series, Parallel and Series configurations; Drive train; Sizing of components; Basics of Micro, Mild, Mini, Plug-in and Fully hybrid.

Reference Books:

1. Electric & Hybrid Vehicles – A.K. Babu, Khanna Publishing House, New Delhi, 2018
2. Electric & Hybrid Vehicles – Design Fundamentals - Iqbal Hussain, Second Edition, CRC Press, 2011.
3. Electric Vehicle Technology Explained - James Larminie, John Wiley & Sons, 2003.
4. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals - Mehrdad Ehsani, Yimin Gao, Ali Emadi, CRC Press, 2010.
5. Electric Vehicle Battery Systems - Sandeep Dhameja, Newnes, 2000.

Course outcomes:

At the end of the course, the student will be able to:

CO1	Understand the basics of electrical vehicle history and components.
CO2	Understand the properties of batteries.
CO3	Understand the electrical machine properties and classifications.
CO4	Understand the properties of electrical vehicle drive systems.
CO5	Understand the concepts of hybrid electric vehicles.

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Course Code	:	MEPE###
Course Title	:	MECHATRONICS
Number of Credits	:	3 (L: 3, T: 0, P: 0)
Prerequisites (Course code)	:	NIL
Course Category	:	PE

Course Objectives:

- To understand the basic concepts and characteristics of measurement systems.
- To learn various types of sensors and transducers various mechanical, electrical and pneumatic actuation systems.
- To learn various mechanical, electrical and pneumatic actuation systems.
- To learn the concepts of digital communications and develop PLC programs.
- To evaluate the performance of mechatronic systems.

Course Content:

UNIT-I: Introduction to Mechatronics: Mechatronics; Importance of Mechatronics; Systems: Measurement systems; Control systems and their types; Closed-loop control System; Automatic water level controller; Sequential controllers-washing machine

Measurement System terminology: Displacement, Position & Proximity Sensors; Velocity and Motion Sensors; Force Sensors; Fluid Pressure Sensors; Flow Sensors; Liquid Level Sensors; Temperature Sensors; Light Sensors; Selection of Sensors.

Unit-II:Mechanical Actuation Systems: Types of motion; Freedom and constraints; Loading; Gear Trains; Pawl & Ratchet; Belt & Chain drives; Bearings: Selection, Ball & Roller bearings; Mechanical aspects of motor selection.

Electrical Actuation Systems: Switches & Relays; Solenoids; D.C Motors; A.C.Motors; Stepper Motors: Specifications and Control of stepper motors; Servomotors: D.C Servomotor and A.C Servomotor.

Pneumatic & Hydraulic Systems: Power supplies; DCV; PCV; Cylinders; Rotary actuators.

Unit-III:Mathematical Model: Introduction to Mathematical model; Mechanical System building blocks; Electrical System building blocks; Fluid System building blocks; Thermal System building blocks.

System Model: Engineering.Systems: Rotational, Translational Systems; Electro-Mechanical System; Hydro-Mechanical System.

Input/Output Systems: Interfacing; Input/output ports; Interface requirements: Buffers, Handshaking, Polling and interrupts, Serial interfacing; Introduction to PIA; Serial communications interface; Example of interfacing of a seven-segment display with a decoder.

Unit-IV: Programmable Logic Controller (PLC): Definition; Basic block diagram and structure of PLC; Input/Output processing; PLC Programming: Ladder diagram, its logic functions, Latching and Sequencing; PLC mnemonics; Timers; Internal relays and Counters; Shift registers; Master and Jump Controls; Data handling; Analog input/output; Selection of PLC.

Unit-V: Design Examples & Advanced Applications in Mechatronics: Design process stages;

Traditional Vs Mechatronics designs; Possible design solutions: Timed switch, Wind-screen wiper motion, Bath room scale; Case studies of Mechatronics systems: A pick-and-place robot, Car park barrier, Car engine management system, Automatic Camera and Automatic Washing Machine only.

Sensors for Condition Monitoring Systems of Production Systems: Examples of Monitoring methods: Vibration monitoring, Temperature monitoring, Wear behavior monitoring; Mechatronics control in automated manufacturing: Monitoring of Manufacturing processes, On-line quality monitoring, Model based systems, Hardware in-the-loop simulation, Supervisory control in manufacturing inspection, Integration of heterogeneous systems.

Reference Books:

1. Mechatronics – W. Bolton, Pearson Education India.
2. A Text Book on Mechatronics – R.K.Rajput, S.Chand& Co, New Delhi.
3. Mechatronics – M.D.Singh & Joshi, Prentice Hall of India.
4. Mechatronics – HMT, Tata McGraw Hill, New Delhi.
5. Mechatronics System – Devadas Shetty, PWS Publishing
6. Exploring Programmable Logic Controllers with applications – Pradeep Kumar Srivatsava, BPB Publications.

Course outcomes

At the end of the course, the student will be able to:

CO1	Describe about various types of sensors and transducers.
CO2	Explain the various mechanical, electrical and pneumatic actuation systems.
CO3	Explain the basic mathematical building blocks for mechanical, electrical, thermal and fluid actuation system and its interfacing of input/output requirements.
CO4	Explain the basic PLC architecture and PLC programming concepts.
CO5	Describe the design examples of mechatronics system. Explain the condition monitoring of production systems using sensors.

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