

**Semester VII (Fourth year]****Branch/Course: Mechanical Engineering**

Semester-7	Code	Course Name	L	T	P	Credits
	PCC-ME 714	Automation in Manufacturing	3	0	2	4
	PEC-MEL703	Elective -III	3	0	0	3
	PEC-MEL704	Elective- IV	3	0	0	3
	OEC-ME 702	Open Elective-II	3	0	0	3
	PROJ-ME 403	Project-III	0	0	10	5
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<b>PCC-ME714</b>	<b>Automation in manufacturing</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To understand the importance of automation in the of field machine tool based manufacturing

To get the knowledge of various elements of manufacturing automation – CAD/CAM, sensors, pneumatics, hydraulics and CNC

To understand the basics of product design and the role of manufacturing automation

**Course Contents:**

Introduction: Why automation, Current trends, CAD, CAM, CIM; Rigid automation: Part handling, Machine tools. Flexible automation: Computer control of Machine Tools and Machining Centers, NC and NC part programming, CNC-Adaptive Control, Automated Material handling. Assembly, Flexible fixturing.

Computer Aided Design: Fundamentals of CAD - Hardware in CAD-Computer Graphics Software and Data Base, Geometric modeling for downstream applications and analysis methods; Computer Aided Manufacturing: CNC technology, PLC, Micro-controllers, CNC-Adaptive Control

Low cost automation: Mechanical & Electro mechanical Systems, Pneumatics and Hydraulics, Illustrative Examples and case studies

Introduction to Modeling and Simulation: Product design, process route modeling, Optimization techniques, Case studies & industrial applications.

### **Course Outcomes:**

Upon completion of this course, the students will get a comprehensive picture of computer based automation of manufacturing operations

### **Text Books:**

(i)MikellP. Groover, Automation, Production Systems, and Computer-integrated Manufacturing, prentice Hall

Serope Kalpakjian and Steven R. Schmid, Manufacturing – Engineering and Technology, 7th edition, Pearson

Yoram Koren, Computer control of manufacturing system, 1st edition

Ibrahim Zeid , CAD/CAM : Theory & Practice, 2nd edition.

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### **PROJ-ME 403(Project III) &PROJ-ME 404 (Project IV)**

### **Objectives:**

It is intended to start the project work early in the seventh semester and carry out both design and fabrication of a mechanical device whose working can be demonstrated. The design is expected to be completed in the seventh semester and the fabrication and demonstration will be carried out in the eighth semester.

<b>PEC-MEL 321</b>	<b>Internal Combustion Engines</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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### **Objectives:**

1. To familiarize with the terminology associated with IC engines.
2. To understand the basics of IC engines.
3. To understand combustion, and various parameters and variables affecting it in various types of IC engines.
4. To learn about various systems used in IC engines and the type of IC engine required for various applications

**Course Contents:** Review of ideal cycles; Details of fuel-air cycles. Combustion in SI and CI engines, Combustion stages, Combustion chambers and Abnormal combustion. Fuel supply systems in SI and CI engines, carburetors, Port fuel injection, Direct injection and Common rail injection. Ignition system, Lubrication system and Cooling system. Testing of IC engines. Engine emissions and control. Advanced IC Engine concepts.

**Course Outcomes:**

Students who have done this course will have a good idea of the basics of IC engines and how different parameters influence the operational characteristics of IC Engines

**Text Books:**

1. Obert E. F, "Internal Combustion Engines and Air Pollution", Harper and Row Publication Inc. NY, 1973.
2. Heisler H, "Advanced Engine Technology", Edward Arnold, 1995.
3. Heywood J. B, "Internal Combustion Engine Fundamentals", McGraw Hill Book Co. NY, 1989
4. Heldt P. M, "High Speed Combustion Engines", Oxford & IBH publishing Co. India, 1985.
5. Stockel M W, Stockel T S and Johanson C, "Auto Fundamentals", The Goodheart, Wilcox Co. Inc., Illinois, 1996.

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<b>PEC-MEL 322</b>	<b>Mechatronic Systems</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Description:**

- (i) To understand the structure of microprocessors and their applications in mechanical devices
- (ii) To understand the principle of automatic control and real time motion control systems, with the help of electrical drives and actuators
- (iii) To understand the use of micro-sensors and their applications in various fields

**Course Contents:**

Introduction: Definition of Mechanical Systems, Philosophy and approach; Systems and Design: Mechatronic approach, Integrated Product Design, Modeling, Analysis and Simulation, Man-Machine Interface;

Sensors and transducers: classification, Development in Transducer technology, Opto-electronics-Shaft encoders, CD Sensors, Vision System, etc.;

Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems;

Smart materials: Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators: Materials, Static and dynamic characteristics, illustrative examples for positioning, vibration isolation, etc.;

Micromechatronic systems: Microsensors, Microactuators; Micro-fabrication techniques LIGA Process: Lithography, etching, Micro-joining etc. Application examples; Case studies Examples of Mechatronic Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.

### **Course Outcomes:**

Upon completion of this course, students will get an overview of mechatronics applications and the use of micro-sensors and microprocessors.

### **Text Books:**

- 1) Mechatronics System Design, Devdas Shetty & Richard A. Kolk, PWS Publishing Company (Thomson Learning Inc.)
- 2) Mechatronics: A Multidisciplinary Approach, William Bolton, Pearson Education
- 3) A Textbook of Mechatronics ,R.K.Rajput, S. Chand & Company Private Limited
- 4) Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, William Bolton, Prentice Hall

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<b>PEC-MEL 323</b>	<b>Microprocessors in Automation</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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### **Objectives:**

To introduce the basic concepts of Digital circuits, Microprocessor system and digital controller

**Course Contents:** Number Systems, codes, digital electronics: Logic Gates, combinational circuits design, Flip-flops, Sequential logic circuits design: Counters, Shift registers. Introduction to 8085 Functional Block Diagram, Registers, ALU, Bus systems, Timing and control signals.

Machine cycles, instruction cycle and timing states, instruction timing diagrams, Memory interfacing.

Assembly Language Programming: Addressing modes, Instruction set, simple programs in 8085; Concept of Interrupt, Need for Interrupts, Interrupt structure, Multiple Interrupt

requests and their handling, Programmable interrupt controller; Interfacing peripherals: Programmable peripheral interface (8255).

Interfacing Analog to Digital Converter & Digital to Analog converter, Multiplexed seven segments LED display systems, Stepper Motor Control, Data Communication: Serial Data communication (8251), Programmable Timers (8253); 8086/8088 Microprocessor and its advanced features,

Introduction to Digital Control: Sampling theorem, Signal conversion and Processing, Z-Transform, Digital Filters, Implementation of Digital Algorithm.

### **Course Outcomes:**

Students who have done this course will have a good idea of the use of microprocessors for automation.

### **Text Books:**

- 1) Digital Electronics: An Introduction to Theory and Practice, William H. Gothmann, PHI Learning Private Limited
- 2) Digital Computer Electronics: An Introduction to Microcomputers, Albert Paul Malvino, Tata McGraw-Hill Publishing Company Ltd.
- 3) Microprocessor Architecture, Programming, and Applications with the 8085, Ramesh Gaonkar, PENRAM International Publishers.
- 4) Digital Control Systems, Benjamin C. Kuo, Oxford University Press ( 2/e, Indian Edition, 2007).
- 5) Microcomputer Experimentation with the Intel SDK-85, Lance A. Leventhal, Prentice Hall

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<b>PEC-MEL 324</b>	<b>Composite Materials</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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### **Objectives:**

1. To understand the mechanical behaviour of composite materials
2. To get an overview of the methods of manufacturing composite materials

### **Contents:**

Definition and applications of composite materials, Fibers- glass, carbon, ceramic and aramid fibers; Matrices- polymer, graphite, ceramic and metal matrices; characteristics of fibers and matrices. Lamina- assumptions, macroscopic viewpoint, generalized Hooke's law, reduction of homogeneous orthotropic lamina, isotropic limit case, orthotropic stiffness matrix, commercial material properties, rule of mixtures, transformation matrix, transformed stiffness.

Manufacturing of composite materials, bag moulding, compression moulding, pultrusion, filament welding, other manufacturing processes

Basic assumptions of laminated anisotropic plates, symmetric laminates, angle ply laminates, cross ply laminates, laminate structural moduli, evaluation of lamina properties, determination of lamina stresses, maximum stress and strain criteria, von Mises Yield

criterion for isotropic materials, generalized Hill's criterion for anisotropic materials, Tsai-Hill's criterion for composites, prediction of laminate failure, thermal analysis of composite laminates

Analysis of laminated plates- equilibrium equations of motion, energy formulation, static bending analysis, buckling analysis, free vibrations, natural frequencies

**Course Outcomes:**

Upon completion of this course, the students will have an overview of the mechanical behaviour and application of composite materials

**Text Books:**

1. Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994.
2. Hyer M.W., Stress Analysis of Fiber- Reinforced Composite Materials, McGraw Hill, 1998.

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<b>PEC-MEL 325</b>	<b>Computer Aided Design</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To provide an overview of how computers can be utilized in mechanical component design

**Contents:**

Fundamentals of Computer Graphics- Product cycle, sequential and concurrent engineering, Computer Aided Design, CAD system architecture, computer graphics, Coordinate systems, 2D and 3D transformations, viewing transformation

Geometric Modeling- representation of curves, Hermite curves, Bezier curves, B-spline curves, rational curves, Techniques of surface modelling, surface patch, Coons and bicubic patches, Bezier and B-spline surfaces, Solid modelling techniques, CSG and B-rep.

Visual realism- hidden line-surface-solid removal algorithms, shading, colouring, computer animation

Assembly of parts- assembly modelling, interferences of positions and orientation, tolerance analysis, mass property calculations, mechanism simulation and interference checking

CAD standards- Graphical Kernel System (GKS), standards for exchange images, Open Graphics Library (OpenGL), Data exchange standards- IGES, STEP, CALS etc., Communication standards

**Course Outcomes:**

Upon completion of this course, the students can use computer and CAD software for modelling mechanical components

**Text Books:**

1. Ibrahim Zeid, Mastering CAD CAM, Tata McGraw Hill Publishing Co. 2007.
2. C. McMohan and J. Browne, CAD/CAM Principles, II edition, Pearson Education, 1999.
3. W. M. Neumann and R.F. Sproul, Principles of Computer Graphics, McGraw Hill, 1989.
4. D. Hearn and M.P. Baker, Computer Graphics, Prentice Hall Inc., 1992.

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<b>PEC-MEL 421</b>	<b>Refrigeration and Air Conditioning</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

1. To familiarize with the terminology associated with refrigeration systems and air conditioning
2. To understand basic refrigeration processes
3. To understand the basics of psychrometry and practice of applied psychometrics
4. To acquire the skills required to model, analyse and design different refrigeration as well as air conditioning processes and components

**Course Content:**

Classification of refrigeration systems

Advanced vapour compression cycles, Refrigerants and their mixtures: properties and characteristics - Ozone depletion and global warming issues - System components: Compressors, Condensers, Expansion devices and Evaporators -Performance matching of components of refrigeration systems

Advanced sorption refrigeration systems and their components.

Review of Psychrometry and Air-conditioning processes - Comfort air conditioning and Cooling load calculations - Applications of AC systems - Concept of enthalpy potential - Air washers, Cooling towers, Evaporative condensers, Cooling and dehumidifying coils.

**Course Outcomes:**

A student who has done the course will have a good understanding of the working principles of refrigeration and air-conditioning systems.

**Text Books:**

1. Gosney, W.B, Principles of Refrigeration, Cambridge University Press, 1982.
2. Stoecker, W.F. and Jones, J.W., Refrigeration and Air conditioning, Tata McGraw Hill, 1986.
3. Arora, C.P., Refrigeration and Air conditioning, Tata McGraw Hill, 2nd Edition, 2000.
4. Kuehn, T.H., Ramsey, J.W. and Threlkeld, J.L., Thermal Environmental Engineering, 3rd Edition, Prentice Hall, 1998.

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<b>PEC-MEL 422</b>	<b>Finite Element Analysis</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

1. To illustrate the principle of mathematical modeling of engineering problems
2. To introduce the basics and application of Finite Element Method

**Contents:**

Historical Background, Mathematical modeling of field problems in engineering, governing equations, discrete and continuous models, boundary and initial value problems, Weighted Residual Methods, Variational formulation of boundary value problems, Ritz technique, Basic concept of Finite Element Method.

One dimensional second order equation, discretization, linear and higher order elements, derivation of shape functions, Stiffness matrix and force vectors, assembly of elemental matrices, solution of problems from solid mechanics and heat transfer, longitudinal vibration and mode shapes, fourth order beam equation, transverse deflections and natural frequencies.

Two dimensional equations, variational formulation, finite element formulation, triangular elements- shape functions, elemental matrices and RHS vectors; application to thermal problems, torsion of non-circular shafts, quadrilateral and higher order elements. Plane stresses and plane strain problems, body forces and thermal loads, plate and shell elements.

Natural coordinate systems, isoparametric elements and shape functions, numerical integration and application to plane stress problems, matrix solution techniques, solution of dynamic problems, introduction to FE software.

**Course Outcomes:**

Upon completion of the course, students will understand the FEM formulation and its application to simple structural and thermal problems

**Text Books:**

1. Reddy J.N., An Introduction to Finite Element Method, 3<sup>rd</sup> ed., Tata McGraw Hill, 2005.
2. Seshu P., Text Book of Finite Element Analysis, Prentice Hall, New Delhi, 2007.
3. Rao S.S., The Finite Element Method in Engineering, 3<sup>rd</sup> ed., Butterworth Heinemann, 2004.
4. Chandraputla&Belegundu, Introduction to Finite Elements in Engineering, 3<sup>rd</sup> ed., Prentice Hall, 1990.

<b>PEC-MEL 423</b>	<b>Power Plant Engineering</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To provide an overview of power plants and the associated energy conversion issues

**Contents:**

Coal based thermal power plants, basic Rankine cycle and its modifications, layout of modern coal power plant, super critical boilers, FBC boilers, turbines, condensers, steam and heating rates, subsystems of thermal power plants, fuel and ash handling, draught system, feed water treatment, binary cycles and cogeneration systems

Gas turbine and combined cycle power plants, Brayton cycle analysis and optimization, components of gas turbine power plants, combined cycle power plants, Integrated Gasifier based Combined Cycle (IGCC) systems.

Basics of nuclear energy conversion, Layout and subsystems of nuclear power plants, Boiling Water Reactor (BWR), Pressurized Water Reactor (PWR), CANDU Reactor, Pressurized Heavy Water Reactor (PHWR), Fast Breeder Reactors (FBR), gas cooled and liquid metal cooled reactors, safety measures for nuclear power plants.

Hydroelectric power plants, classification, typical layout and components, principles of wind, tidal, solar PV and solar thermal, geothermal, biogas and fuel cell power systems

Energy, economic and environmental issues, power tariffs, load distribution parameters, load curve, capital and operating cost of different power plants, pollution control technologies including waste disposal options for coal and nuclear plants.

**Course Outcomes:**

Upon completion of the course, the students can understand the principles of operation for different power plants and their economics.

**Text Books:**

1. Nag P.K., Power Plant Engineering, 3<sup>rd</sup> ed., Tata McGraw Hill, 2008.
2. El Wakil M.M., Power Plant Technology, Tata McGraw Hill, 2010.
3. Elliot T.C., Chen K and Swanekamp R.C., Power Plant Engineering, 2<sup>nd</sup> ed., McGraw Hill, 1998.

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<b>PEC-MEL 424</b>	<b>Gas Dynamics and Jet Propulsion</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

1. To understand the features of compressible isentropic flows and irreversibilities like shocks.
2. To provide a basic knowledge of jet and rocket propulsion technologies.

**Contents:**

Compressible flow, definition, Mach waves and Mach cone, stagnation states, Mass, momentum and energy equations of one-dimensional flow, Isentropic flow through variable area ducts, nozzle s and diffusers, subsonic and supersonic flow I variable area ducts, choked flow, Area-Mach number relations for isentropic flow

Non-isentropic flow in constant area ducts, Rayleigh and Fanno flows, Normal shock relations, oblique shock relations, isentropic and shock tables

Theory of jet propulsion, thrust equation, thrust power and propulsive efficiency, Operating principle and cycle analysis of ramjet, turbojet, turbofan and turboprop engines.

Types of rocket engines, propellants & feeding systems, ignition and combustion, theory of rocket propulsion, performance study, staging, terminal and characteristic velocity, space flights

**Course Outcomes:**

Upon completion of this course, the students will be able to apply gas dynamics principles to jet and space propulsion systems

**Text Books:**

1. Ahmed F. El-Sayed, Aircraft Propulsion and Gas Turbine Engines, CRC Press, 2008.
2. H.S. Mukunda, "Understanding Aerospace Chemical Propulsion", Interline Publishing, 2004.
3. Hill P. and Peterson C., Mechanics & Thermodynamics of Propulsion, Addison Wesley, 1992.
4. Zucrow N. J., Aircraft and Missile Propulsion, Vol.I& II, John Wiley, 1975.
5. Sutton G.P., Rocket Propulsion Elements, John Wiley, New York, 1986.

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<b>PEC-MEL 425</b>	<b>Process Planning and Cost Estimation</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To introduce process planning concepts to make cost estimation for various products

**Contents:**

Introduction of Process Planning- methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection

Process planning activities- process parameter calculation for various production processes, selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, economics of process planning, case studies

Introduction to cost estimation- importance of costing and estimation, methods of costing, elements of cost estimation, types of estimates, estimating procedure, estimation of labor cost, material cost, allocation of overhead charges, calculation of depreciation cost

Machining time estimation- importance of machine time calculation, machining time for different lathe operations, drilling and boring time calculations, Machining time calculation for Milling, Shaping, Planing and Grinding

Production costs- different production processes for different jobs, estimation of forging cost, estimation of welding cost, estimation of foundry cost, estimation of machining cost

**Course Outcomes:**

Upon completion of this course, the students will be able to use the concepts of process planning and cost estimation for various products

**Text Books:**

1. Peter Scalon, Process Planning, Design/ Manufacture Interface, Elsevier Sci.&Tech. 2002.
2. Ostwaal P.F. and Munez J., Manufacturing Processes and Systems, 9<sup>th</sup> ed., John Wiley 1998.
3. Chitale A.V. and Gupta R.C., Product Design and Manufacturing, 2<sup>nd</sup> ed., Prentice Hall 2002.

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<b>PEC-MEL 431</b>	<b>Principles of Management</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To understand the principles of management and their application to the functioning of an organization

**Contents:**

Definition of management, science or art, manager vs entrepreneur; Types of managers- managerial roles and skills; Evolution of management- scientific, human relations, system and contingency approaches; Types of Business Organizations, sole proprietorship, partnership, company, public and private enterprises; Organization culture and environment; Current trends and issues in management.

Nature and purpose of Planning, types of Planning, objectives, setting objectives, policies, Strategic Management, Planning Tools and Techniques, Decision making steps & processes.

Nature and purpose of Organizing, formal and informal organization, organization structure, types, line and staff authority, departmentalization, delegation of authority, centralization and decentralization, job design, human resource management, HR planning, Recruitment selection, Training & Development, Performance Management, Career planning and Management.

Directing, individual and group behavior, motivation, motivation theories, motivational techniques, job satisfaction, job enrichment, leadership, types & theories of leadership, effective communication.

Controlling, system and process of controlling, budgetary and non-budgetary control techniques, use of computers and IT in management control, productivity problems and management, control and performance, direct and preventive control, reporting.

**Course Outcomes:**

Upon completion of this course, the students will get a clear understanding of management functions in an organization

**Text Books:**

1. Robins S.P. and Couiter M., Management, Prentice Hall India, 10<sup>th</sup> ed., 2009.
2. Stoner JAF, Freeman RE and Gilbert DR, Management, 6<sup>th</sup> ed., Pearson Education, 2004.
3. Tripathy PC & Reddy PN, Principles of Management, Tata McGraw Hill, 1999.

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<b>PEC-MEL 432</b>	<b>Automobile Engineering</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To understand the construction and working principle of various parts of an automobile

**Contents:**

Types of automobiles, vehicle construction and layouts, chassis, frame and body, vehicle aerodynamics, IC engines- components, function and materials, variable valve timing (VVT). Engine auxiliary systems, electronic injection for SI and CI engines, unit injector system, rotary distributor type and common rail direct injection system, transistor based coil ignition & capacitive discharge ignition systems, turbo chargers (WGT, VGT), engine emission control by 3-way catalytic converter system, Emission norms (Euro & BS).

Transmission systems, clutch types & construction, gear boxes- manual and automatic gear shift mechanisms, Over drive, transfer box, flywheel, torque converter, propeller shaft, slip joints, universal joints, differential and rear axle, Hotchkiss drive and Torque tube drive.

Steering geometry and types of steering gear box, power steering, types of front axle, types of suspension systems, pneumatic and hydraulic braking systems, antilock braking system (ABS), electronic brake force distribution (EBD) and traction control.

Alternative energy sources, natural gas, LPG, biodiesel, bio-ethanol, gasohol and hydrogen fuels in automobiles, modifications needed, performance, combustion & emission characteristics of alternative fuels in SI and CI engines, Electric and Hybrid vehicles, application of Fuel Cells

**Course Outcomes:**

Upon completion of this course, students will understand the function of each automobile component and also have a clear idea about the overall vehicle performance.

**Text books:**

1. Kirpal Singh, Automobile Engineering, 7<sup>th</sup> ed., Standard Publishers, New Delhi, 1997.
2. Jain K.K. and Asthana R.B., Automobile Engineering, Tata McGraw Hill, New Delhi, 2002.
3. Heitner J., Automotive Mechanics, 2<sup>nd</sup> ed., East-West Press, 1999.
4. Heisler H., Advanced Engine Technology, SAE International Publ., USA, 1998.

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<b>PEC-MEL 433</b>	<b>Design of Transmission Systems</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To learn about the design procedures for mechanical power transmission components

**Contents:**

Flexible transmission elements- design of flat belts & pulleys, selection of V-belts and pulleys, selection of hoisting wire ropes and pulleys, design of chains and sprockets

Gear transmission- speed ratios and number of teeth, force analysis, tooth stresses, dynamic effects, fatigue strength, factor safety, gear materials; Design of straight tooth spur gear and parallel axis helical gears based on strength and wear considerations, pressure angle in the normal and transverse plane; equivalent number of teeth and forces for helical gears.

Straight bevel gear- tooth terminology, tooth forces and stresses, equivalent number of teeth. Estimating the dimensions of a pair of straight bevel gears; Worm gear, merits & demerits, terminology, thermal capacity, materials, forces & stresses, efficiency, estimating the size of worm gear pair. Cross helical gears, terminology, helix angles, sizing of a pair of helical gears.

Gear box- geometric progression, standard step ratio; Ray diagram, kinematics layout; Design of sliding mesh gear box- Design of multi-seed gear box for machine tool applications; constant mesh gear box, speed reducer unit; Variable speed gear box; Fluid couplings, Torque converters for automotive applications.

Cam design, types: pressure angle and undercutting base circle determination, forces and surface stresses; Design of plate clutches, axial clutches, cone clutches, internal expanding rim clutches; Electromagnetic clutches; Band and Block brakes, external shoe brakes, internal expanding shoe brake.

**Course Outcomes:**

Upon completing this course the students will be able to design transmission systems for engines and machines.

**Text Books:**

1. Shigley J., Mischke C., Budynas R. and Nisbett K., Mechanical Engineering Design, 8<sup>th</sup> ed., Tata McGraw Hill, 2010.
2. Jindal U.C., Machine Design: Design of Transmission System, Dorling Kindersley, 2010.
3. Maitra G. and Prasad L., Handbook of Mechanical Design, 2<sup>nd</sup> ed., Tata McGraw Hill, 2001.



<b>PEC-MEL 434</b>	<b>Total Quality Management</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To facilitate the understanding of total quality management principles and processes

**Contents:**

Introduction, need for quality, evolution of quality; Definitions of quality, product quality and service quality; Basic concepts of TQM, TQM framework, contributions of Deming, Juran and Crosby. Barriers to TQM; Quality statements, customer focus, customer orientation & satisfaction, customer complaints, customer retention; costs to quality.

TQM principles; leadership, strategic quality planning; Quality councils- employee involvement, motivation; Empowerment; Team and Teamwork; Quality circles, recognition and reward, performance appraisal; Continuous process improvement; PDCE cycle, 5S, Kaizen; Supplier partnership, Partnering, Supplier rating & selection.

The seven traditional tools of quality; New management tools; Six sigma- concepts, methodology, applications to manufacturing, service sector including IT, Bench marking process; FMEA- stages, types.

TQM tools and techniques, control charts, process capability, concepts of six sigma, Quality Function Development (QFD), Taguchi quality loss function; TPM- concepts, improvement needs, performance measures.

Quality systems, need for ISO 9000, ISO 9001-9008; Quality system- elements, documentation,; Quality auditing, QS 9000, ISO 14000- concepts, requirements and benefits; TQM implementation in manufacturing and service sectors.

**Course Outcomes:**

Upon completion of this course, the students will be able to use the tools and techniques of TQM in manufacturing and service sectors.

**Text Books:**

1. Besterfield D.H. et al., Total qualityManagement, 3<sup>rd</sup> ed., Pearson Education Asia, 2006.
2. Evans J.R. and Lindsay W.M., The management and Control of Quality, 8<sup>th</sup> ed., first Indian edition, Cengage Learning, 2012.
3. Janakiraman B. and Gopal R.K., Total Quality Management, Prentice Hall India, 2006.
4. Suganthi L. and Samuel A., Total Quality Management, Prentice Hall India, 2006.

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<b>PEC-MEL 435</b>	<b>Energy Conservation and Management</b>	<b>3L:0T:0P</b>	<b>3 credits</b>
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**Objectives:**

To understand the energy data from industries and carry out energy audit for energy savings

**Contents:**

Introduction to energy & power scenario of world, National Energy consumption data, environmental aspects associated with energy utilization; Energy Auditing- need, types, methodology and barriers, role of energy managers, instruments of energy auditing.

Components of EB billing, HT and LT supply, transformers, cable sizing; Concept of capacitors, power factor improvement, harmonics; Electric motors- motor efficiency computation, energy efficient motors; Illumination- Lux, Lumens, types of lighting, efficacy, LED lighting and scope of energy conservation in lighting.

Thermal systems, Boilers, Furnaces and Thermic Fluid heaters- efficiency computation and energy conservation measures; Steam distribution and usage, steam traps, condensate recovery, flash steam utilization; Insulation & Refractories.

Energy conservation in major utilities; pumps, fans, blowers, compressed air systems, Refrigeration & Air Conditioning systems, Cooling Towers, DG sets.

Energy Economics- discount period, payback period, internal rate of return, net present value; Life Cycle costing- ESCO concept.

**Course Outcomes:**

Upon completion of this course, the students will be able to perform of energy auditing for the energy consumption of industries.

**Text Books:**

1. Witte L.C. , Schmidt P.S. and Brown D.R., Industrial Energy Management and Utilization, Hemisphere Publ., Washington, 1988..
2. Callagh P.W., Design and Management for Energy Conservation, Pergamon Press, Oxford, 1981.
3. Murphy W.R. and McKay G., Energy Management, Butterworths, London, 1987.
4. Energy Manager Training Manual , Bureau of Energy Efficiency (BEE) under Ministry of Power, GOI, 2004 (available at [www.energymanagertraining.com](http://www.energymanagertraining.com)).

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