FACULTY OF ENGINEERING

Scheme of Instruction & Examination

(AICTE Model Curriculum for the Academic Year 2020-2021)

and

Syllabi

B.E. V and VI Semester

of

Four Year Degree Programme

in

Mechanical Engineering

(With effect from the academic year 2020– 2021)
(As approved in the faculty meeting held on - -2020)

Issued by

Dean, Faculty of Engineering

Osmania University, Hyderabad – 500 007

2020

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Mechanical Engineering) V – SEMESTER

S.No.	Course Code	CourseTitle	SchemeofInstructions				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC501ME	Fluid Mechanics and Hydraulic Machinery	3	-	-	3	30	70	3	3
2	PC502ME	Design of Machine Elements	3	-	-	3	30	70	3	3
3	PC503ME	Dynamics of Machines	3	-	-	3	30	70	3	3
4	PC504ME	Metal Cutting and Machine Tools	3	-	-	3	30	70	3	3
5	PC505ME	Heat Transfer	3	-	-	3	30	70	3	3
LaboratoryCourse										
6	PC591ME	Thermal Engineering Lab-2	-	-	2	2	25	50	3	1
7	PC592ME	Dynamics of Machines Lab	-	-	2	2	25	50	3	1
8	PC593ME	Fluid Mechanics and Hydraulic Machinery Lab	-	-	2	2	25	50	3	1
		Total	15	-	06	21				18

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

SCHEME OF INSTRUCTION & EXAMINATION
B.E. (Mechanical Engineering) VI – SEMESTER

S.No.	Course Code	CourseTitle	SchemeofInstructions				SchemeofExamination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Durationin Hours	
Theory Course										
1	PC601ME	Machine Design	3	-	-	3	30	70	3	3
2	PC602ME	Metrology and Instrumentation	3	-	-	3	30	70	3	3
3	PC603ME	Finite Element Analysis	3	-	-	3	30	70	3	3
4	PEME - 1	Professional Elective – I	3	-	-	3	30	70	3	3
5	PEME - 2	Professional Elective – II	3	-	-	3	30	70	3	3
6	OEME - 1	Open Elective – 1	3	-	-	3	30	70	3	3
LaboratoryCourse										
7	PC691ME	Metrology and Machine Tools Lab	-	-	2	2	25	50	3	1
8	PC692ME	Computer Aided Engineering Lab	-	-	2	2	25	50	3	1
9		Summer Internship*								2
		Total	18	00	04	22				22

Open Elective - 1 (OE611ME) : Industrial Robotics (Not for Mechanical / Prod. / Automobile)

PROFESSIONAL ELECTIVE - I	
PE611ME	CAD/CAM
PE612ME	Automobile Engineering
PE613ME	Modern Machining and Forming Methods

Professional Elective-II		
S. No.	**Course Code**	**Course Title**
1.	PE621ME	Thermal Turbo Machines
2.	PE622ME	Production and Operations management
3.	PE623ME	Design For Manufacture

PC: Professional Core PE: Professional Elective OE: Open Elective
L: Lecture T: Tutorial P: Practical D: Drawing
CIE: Continuous Internal Evaluation SEE: Semester End Evaluation (Univ. Exam)

* *At the end of VI semester students should undergo summer Internship - Credits for Summer Internship will be awarded in VII semester*

Course Code	Course Title						Core/Elective
PC501ME	**Fluid mechanics & Hydraulic machines**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
Mathematics& mechanics-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

It is intended to make the students to

1. Know various fluid properties, concepts and methods of fluid measurement.
2. Understand the basic concepts and principle of fluid flow.
3. Study different equations of fluid motion and fluid dynamics.
4. Analyze different flow characteristics of laminar flows.
5. Understand the working principle of hydraulic turbines and pumps and their performance**.**

Course Outcomes

After completing this course, , the student is able to

1. Distinguish the properties of the fluids and different types of pressure and measure them.
2. Explain different types of flows and analyze them.
3. Analyze the flow between parallel plates and in pipes and also calculate drag and lift coefficients.
4. Demonstrate the working principles of various hydraulic turbines and estimate their performance.
5. Demonstrate the working principles of various hydraulic pumps and estimate their performance.

UNIT – I

Basic Concepts and Properties of Fluid

Definition, distinction between solid and fluid, , Properties of fluids, density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension, units and dimensions.

Fluid statics

Concept of fluid static pressure, absolute and gauge pressures, pressure measurements by manometers and pressure gauges.

UNIT-II

Fluid Kinematics

Flow visualization, lines of flow, types of flow, velocity field and acceleration, Continuity equation (one and three-dimensional differential forms), Equation of streamline, stream function, velocity potential function, circulation, flow net**.**

Fluid Dynamics

Equations of motion, Euler's equation along a streamline, Bernoulli's equation, applications. Venturi meter, Orifice meter, Pitot tube.

UNIT-III

Incompressible Fluid Flow

Viscous flow, Shear stress-pressure gradient relationship, laminar flow between parallel plates, Laminar flow through circular tubes (Hagen poiseulle's), Hydraulic and energy gradient lines**.**

Flow through pipes

Darcy- Weisback's equation, pipe roughness, friction factor, minor losses, flow through pipes in series and in parallel, power transmission, Boundary layer flows, boundary layer thickness, boundary layer separation, drag and lift coefficients.

UNIT IV

Hydraulic Turbines

Definition and classifications, Pelton turbine, Francis turbine, propeller turbine, Kaplan turbine, working principles, velocity triangles, work done, specific speed. Efficiencies, performance curve for turbines.

UNIT V

Hydraulic Pumps

Pumps: definition and classifications, Centrifugal pump: classifications, working principles, velocity triangles, specific speed, efficiency and performance curves. Reciprocating pump: classification, working principles, indicator diagram, performance curves, cavitation in pumps, Rotary pumps: working principles of gear and vane pumps.

Suggested Reading

1. **Streeter, V.L., and Wylie, E.B., "Fluid Mechanics", McGraw-Hill, 1983.**
2. **Modi & Seth "Hydraulic and Fluid Mechanics" – standard book house, 2002.**
3. **Bansal, R.K., "Fluid Mechanics and Hydraulics Machines", (5th edition), Laxmi publications (P) Ltd. Delhi, 1995.**
4. **Kumar D. S., "Fluid Mechanics and Fluid Power Engineering", S. K. Kataria & Sons.**
5. **White, F.M., "Fluid Mechanics", Tata McGraw-Hill, 5th Edition, New Delhi, 2003.**
6. **Som, S.K., and Biswas, G., "Introduction to fluid mechanics and fluid machines", Tata McGraw-Hill, 2nd edition, 2004.**

Course Code	Course Title						Core/Elective
PC502ME	DESIGN OF MACHINE ELEMENTS						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
	3	--	--	--	30	70	3

Course Objectives:

- Importance of codes, materials, manufacturing processin design of mechanical components
- Importance of theories of failure and effects of fatigue and stress concentration on the life of the component
- Learn the concepts required to design machine components like keys, shafts, couplings
- Will learn to determine size of rivets, welds and cotter joints for specific applications
- Will Understand the concepts used for designing machine components like cotters, bolts, nuts

Course Outcomes:

- Identify & Use codes and standards, selection proper material & perform static design.
- Analyze cyclic loading conditions and provide fatigue design of components
- Analyze machine elements like keys, shafts and couplings,
- Evaluate various joining techniques like welding, riveting and cotter joints.
- Synthesize an d design screw threads for fasteners and power screw applications.

UNIT-I

Steps involved in Design, Design considerations of Machine Elements, Materials used and their specifications. Codes and standards used in design. Practice of using Design data book. Concept of Aesthetics & Ergonomics in design, Preferred numbers. Manufacturing considerations in design. Concept of Value analysis, Principles of concurrent design,

Types of loads and simple stresses. Principal stresses, Stresses due to Biaxial and Triaxial loads. Stress concentration effects, Factor of safety. Theories of failures. Design of components subjected to impact loading.

UNIT-II

Design for Fatigue: Fluctuating stresses, fatigue strength and endurance limit Stress concentration factor and Notch sensitivity. Factors affecting fatigue strength. S-N diagram, Soderberg and Modified Goodman's diagrams for fatigue design, Cumulative fatigue - Miner's rule.

UNIT-III

Design of shafts: solid, hollow and splined shafts under torsion and bending loads. Design of keys. Design of couplings – Industrial Flange coupling, Flexible rubber bush couplings.

UNIT-IV

Design of Joints: Cotter and Knuckle joints. Design of rivetted and welded joints under direct and eccentric loads.

UNIT-V

Design of Screw threads: Design of bolts and nuts, Locking devices for nuts, Bolts of uniform strength. Design of gasket joints, Bolted joints under eccentric loads, Differential and Compound Screws, Design of power Screws and screw jack.

Suggested Reading:

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw-Hill Publ, 3rd Edn. 2010.
2. J.E. Shigley & Charles R. Mischke "Mechanical Engineering Design", Tata McGraw-Hill.,6th ed.2010.
3. P. Kannaiah, Machine Design, Sci-Tech Publ., 2009.
4. P.C. Sharma & D.K. Aggarwal, "Machine Design", S.K. Kataria & Sons, 10th edn, 2003
5. V. B. Bhandari, "Design Data Book " 2nd edition, ", Tata McGraw-Hill Publ, 2019

Note : Solution of Numerical problems using Design data book should be practiced.

Course Code	Course Title						Core/Elective
PC503ME	DYNAMICS OF MACHINES						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
Kinematics of Machines	3	--	--	--	30	70	3

Course Objectives:

- To know effect of inertia of links, and external forces on the input torque, and forces developed at joints in typical mechanisms in motion; understand the gyroscopic couple and its effect on vehicles in motion.
- To know the working principles and characteristics of typical governors, as also the function of flywheels.
- To know the concept of unbalancing rotating and reciprocating masses in single and multi-cylinder in line and radial engines.
- To understand the phenomena of free of free and forced, including the effect of damping for single dof systems, and concepts of isolating vibration.
- To determine natural frequencies of undammed, damped and forced vibrating systems of one, two and multi degree freedom systems.

Course Outcomes:

- Analyse static and dynamic forces in slider crank and other mechanisms; determine the magnitude of gyroscopic couple and its effect on vehicles in motion.
- Evaluate the performance of various types of governors and design flywheels considering speed and energy fluctuation
- Analyse problems of balancing in rotating and reciprocating machinery.
- Evaluate the natural frequencies of single and two degree of freedom systems in free and forced vibration mode, also considering the effect of damping.
- Determine the natural frequencies and mode shapes of multi degree of freedom systems, including by Dunkerley, Raleigh and Holzer methods.

UNIT-I

Static and Dynamic Force Analysis: *Static equilibrium:* Constraint and Applied forces, Static Force analysis of Single slider crank mechanism without Friction, Principle of Superposition.

Dynamic Equilibrium: d'Alambert's Principle, Equivalent offset inertia force, Dynamic force Analysis of Slider Crank Mechanism,

Engine Force Analysis: Piston effort, Force along connecting rod, thrust on sides of cylinder, crank effort. Thrust on bearing. Dynamically Equivalent System for Connecting Rod.

Gyroscope: Gyroscopic Couple, gyroscopic effects on aeroplanes, naval ships.

Stability of two wheel vehicle only.

UNIT-II

Governors: Working principle of governor, Classification & types of governors, analysis of Watt, Porter, and Hartnell governors. Characteristics of governors:

Controlling Force, Stability, Isochronism, Sensitivity, Power and Effort of governors.

Flywheels: Functions, Differences between flywheel and governor, turning moment diagrams, flywheel analysis for I-C Engines and presses.

UNIT - III

Balancing: Static balancing, Dynamic balancing, balancing of several masses rotating in several planes, consideration of bearing forces, balancing of reciprocating masses, primary balancing shaking forces in single cylinder engine, partial balancing and its effects, secondary balancing.

UNIT - IV

Vibrations: Vibrations of Single degree freedom system (axial, transverse and torsional), Equivalent system of combination of springs, Stepped shaft, Whirling speed of shafts.

Damped Vibrations: Types of damping, Vibrations with viscous damping

Forced Damped Vibrations: Magnification factor, Resonance, Vibration isolation and Transmissibility.

UNIT –V

Vibration Analysis of Multi Degree Freedom Systems: Torsional Vibrations of Two rotor, three rotor and Geared systems. Natural frequencies of two degree freedom systems Modes of vibration approximate methods for determining natural frequencies: Dunkerley's method, Rayleigh's method. Holzer's method (only Theory).

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. Thomas Bevan, the Theory of Machines, CBS Publishers & Distributors, 2004.
3. John J.Uicker, Jr. Gordon, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
4. J.S. Rao and Gupta, Theory and Practice of Mechanical Vibrations, Prentice Hall, 1984.
5. R.L.Nortan, "Kinematics and Dynamics of Machinery", Tata McGraw Education Pvt. Ltd , New Delhi, 2009.
6. Ghosh and Mallik, Theory of Mechanisms and Machines, Affiliated East-West Press, 1988.

Course Code	Course Title						Core/Elective
PC504ME	**METAL CUTTING & MACHINE TOOLS**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

- To learn the tool material, geometry and mechanics of metal cutting for turning, drilling and milling.
- To know the heat distribution, tool wear, tool life, and machinability
- To learn the principle and working of various machine tools like lathe, shaper, planer, milling, drilling and grinding machines etc.
- To learn various types of fixtures, conventional and unconventional machining processes.

Course Outcomes:

- Understand the cutting tool geometry, mechanism of chip formation and mechanics of orthogonal cutting.
- Understand the thermal aspects of metal cutting, influence of tool wear on tool life and machinability.
- Identify basic parts and operations of machine tools including lathe, shaper, planer, milling, drilling, and boring machines.
- Design locating and clamping devices to produce a component.
- Understand the principles of various finishing processes and gear manufacturing processes
- Understand the principle and working of various unconventional machining processes.

UNIT-I

Cutting Tool Materials: High carbon steel, HSS, Stellites, Carbides, Coated carbides, Diamonds, Tool material properties; **Tool Geometry:** Nomenclature of single point cutting tool by ASA & ORS systems. Geometry of drills, milling cutters; **Chip Formation:** Types of chips, BUE, Chip breakers; **Machining:** Orthogonal and oblique cutting, Mechanics of metal cutting, Merchant's analysis, Shear angle, Solutions of Merchant and Lee & Shafer.

UNIT-II

Thermal Aspects of Metal Cutting: Sources of heat and heat distribution, various methods of measurement of temperature, Cutting fluids and applications; **Tool Wear, Tool Life and Machinability:** Types of wear, mechanism of tool wear, Tool life & Machinability, Machinability index. Taylor's tool life equation; **Economics of Machining:** Tool life for maximum production, minimum cost.

UNIT-III

Machine Tools: Constructional features and specifications of machine tools, various operations on Lathe, Types of Lathes - capstan and turret Lathes; Drilling, Milling and Boring machines. Indexing methods, differences between shaper, planer and slotter, Tool holding and work holding devices Quick return mechanisms.

UNIT-IV

Grinding Machines: Types of grinding, Abrasives and bonds used for grinding wheels. Specification and selection of grinding wheels; Broaching, Lapping, Honing, Polishing, Buffing, Super Finishing and Burnishing.

Screws and Gear Manufacturing: Tapping, Chasers, Thread rolling, Thread milling, Thread grinding. Gear shaping, Gear hobbing, Gear shaving and grinding.

UNIT-V

Jigs and Fixtures: Design principles for location and clamping. Quick clamping devices Types of Jigs and fixtures. Applications of Jigs and Fixtures.

Unconventional Machining: Principle of working, merits, demerits and applications of USM, AJM, EDM, ECM, LBM and EBM

Suggested Reading:

1. B.L. JuneJa and Shekon, "Fundamentals of Metal Cutting & Machines Tools", Wiley Eastern Ltd. 1987.
2. P.N. Rao, "Manufacturing Technology – Metal Culling & Machine Tools", Vol. 2, Tata McGraw Hill Education Pvt. Ltd, 2010.
3. Amitab Ghosh and Mallick, "Manufacturing Science", Affiliated East West Press 1985.
4. P.K Misha, "Non Traditional Machining Processes", Narosa Publications, 2006.
5. V.K.Jain “Advanced Machining Processes“ Allied Publishers, Hyderabad, 2011.
6. A. Bhattacharyya, “Metal Cutting Theory and Practice” New Central Book Agency (P) Ltd. Calcutta, 1996.
7. Stephan Radavich, “Gear Manufacturing”, CRC Press, ,1 Edn,2011

Course Code	Course Title						Core/Elective
PC505ME	**HEAT TRANSFER**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
FLUID MECHANICS	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- The basic concepts of heat transfer Obtaining centroids and moments of inertia for various regular and irregular areas.
- The concepts of conduction, convection, radiation and heat exchangers applicable for commercial and industrial use
- The applications of various experimental heat transfer correlations in engineering applications.
- Thermal analysis and sizing of heat exchanger.
- solving problems on different modes of heat transfer which are related to thermal power plants, refrigeration and air conditioning

Course Outcomes

After completing this course, the student will be able to:

1. To understand the basic concepts of heat transfer.
2. To understand the concepts of heat transfer through extended surfaces.
3. To Familiarize with time dependent heat transfer and compute convective heat transfer coefficients in forced, natural convection.
4. To understand radiation heat transfer
5. To understand , heat exchangers and mechanism involved in boiling and condensation.

UNIT – I

Conduction: Modes of Heat Transfer, Laws of Heat Transfer - Fourier, Newton, Stefan-Boltzmann General conduction equation in cartesian, cylindrical and spherical coordinates, One dimensional steady state conduction through slabs, hollow cylinders and spheres with and without heat generation, Effects of variable thermal conductivity in heat transfer of one dimensional steady state conduction of plate, cylinders and spheres, Steady state heat transfer through composite slabs, cylinders and spheres, Critical radius of insulation.

UNIT – II

Fins: Heat transfer analysis of tips with heat dissipation environment - rectangular straight and pin fins, Application of fin to temperature measurement, unsteady state conduction, Lumped parameter, analysis of a body with negligible internal temperature gradients, Transient heat transfer analysis of finite slab with specified temperature and convective boundary conditions, Use of Grober and Heisler charts for solving problems of infinite slabs, cylinders and spheres.

UNIT-III

Free and forced convection: Dimensional analysis and its use in free and forced convection, Buckingham theorem, Physical significance of different dimensionless numbers, Application of Von-Karman integral equation for the analysis of thermal boundary layer in forced convection of flat plate, Reynold's analogy for flow over plane surfaces, calculation of heat transfer for flow over plates, cylinders and for flow through tubes in free and forced convection using empirical formulae.

UNIT –IV

Radiation: Definition of absorptivity, reflectivity and transmissivity, Concept of black-body and emissivity. Kirchoffs law, Planck's black body spectral distribution, Wien's and Steffan Boltzmann law, Monochromatic and total emissive power, radiant heat exchange between two gray surfaces, Shape factor, Thermal circuit for radiant heat exchange between infinite parallel plates and between concentric, cylinders, Enclosures with black and gray surfaces, Radiation shields and re-radiation surfaces.

UNIT – V

Heat Exchangers: Classification and applications of heat exchangers in industry, Analysis and design of counter flow and parallel flow heat exchanger, Fouling factors, solving problems for multi pass heat exchanger using non dimensional parameter plots.

Change of Phase: Boiling-pool boiling regimes nucleate pool boiling, effect of surface wettability on bubble contact angle, Critical heat flux, boiling in forced convection, Condensation: Film condensation, Drop wise condensation, Condensation film thickness, Heat transfer coefficient in film condensation.

Suggested Readings:

1. Holman, J.P., "Heat Transfer", McGraw Hill Publication, New Delhi, 2010 2.
2. Rajput, R.K., "Heat and Mass Transfer", S. Chand & Company Ltd, New Delhi, 2004.
3. Yadav, R., Sanjay. and Rajay., "Heat and Mass Transfer ', Central Publishing House, Allahabad, 2004
4. Sachdeva,R.C., "Fundamentals of Engineering Heat and Mass Transfer ", New Age International (P) Ltd Publishers, New Delhi,
5. Arora, S.C. and Domkandwar., "A course in Heat and Mass Transfer ", DhanpatRai& Sons, New Delhi, 2004.

Course Code	Course Title						Core/Elective
PC591ME	**THERMAL ENGINEERING Lab - II**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- Determining thermal conductivity of an insulating powder in composite slab or cylinder. The concepts of conduction, convection, radiation and heat exchangers applicable for commercial and industrial use
- Evaluating the heat transfer coefficients under natural convection and forced convection phenomena Thermal analysis and sizing of heat exchanger.
- determining the necessary constants pertaining to radiation
- understanding the working principles of axial flow fan and its overall efficiency
- estimating overall efficiency of a centrifugal compressors and pressure distribution over cylinder and an aerofoil section on turbo machines.

Course Outcomes

Aftercompletingthis course, thestudentwillbe ableto:

1. Interpret the link between refrigeration effects, work done and COP of the system, describe different methods adopted to evaluate COP, list the different psychrometric processes and describe how those processes can be maintained
2. Calculate the overall efficiency of centrifugal blower and axial flow fan at different volume flow rates, show the variation of overall efficiency with load and speed graphically To understand radiation heat transfer, heat exchangers and mechanism involved in boiling and condensation.
3. . Identify the various components of low speed wind tunnel, plot a graph showing variation of pressure over the entire length of aerofoil blade and also evaluate the lift and drag coefficient values for a given aerofoil blade at different angle of assign
4. Describe the modes of heat transfer, calculate thermal conductivity, heat transfer coefficient subjected to natural and forced convection environment and Stefan Boltzmann constant value of thermal radiation.
5. Express the working principle of heat exchangers and its application in real life, calculate the LMTD and effectiveness of a given heat exchanger for both parallel and counter flows.

List of Experiments:

1. Determination of thermal conductivity of metal bar
2. Determination of thermal conductivity of composite wall.
3. Determination of the efficiency of pin-fin subjected to natural and forced convection
4. Determination of effectiveness of parallel flow and counter flow heat exchanger

5. Determination of emissivity of given test plate
6. Determination of Stefan Boltzmann constant.
7. Determination of COP of the Air conditioning system
8. Determination of percentage relative humidity and study of humidification and dehumidification process in Air Conditioning systems
9. .Determination of COP of refrigeration systems using capillary tube/ thermostatic expansion valve
10. Determination of overall efficiency of centrifugal blower
11. Determination of overall efficiency of axial flow fan
12. Pressure distribution on symmetrical and non-symmetrical specimen in wind tunnel
13. Measurement of lift and drag force of the models in wind tunnel test section

Note: At least ten experiments should be conducted.

Course Code	Course Title						Core/Elective
PC592ME	**DYNAMICS OF MACHINES LAB**						**Core**
Prerequisite	**Contact Hours per week**				**CIE**	**SEE**	**Credits**
	L	**T**	**D**	**P**			
Theory of Machines	**--**	**--**	**--**	**2**	**25**	**50**	**1**

Course Objectives:

- To understand the effects and importance of kinematic and dynamic analysis of mechanisms
- To understand effects and analysis of Single degree freedom vibration systems
- To study the gyroscope, governors and cams
- To carry out the static and dynamic analysis of four bar mechanisms and drives

Course Outcomes:

- To experimentally quantify the effect of inertia forces in systems like flywheel, gyroscope and governors.
- To evaluate vibrational characteristics of various systems experimentally.
- To Synthesize balancing method of multi plane rotating masses.

List of Experiments

1. Centrifugal Governors: Experiment on Performance Characteristic Curves.
2. Estimation of Gyroscopic Couple & Understanding of Gyroscopic Effects on a rotating disc.
3. Static and Dynamic Balancing of Rotating Masses.
4. Determination of Moment of Inertia of Connecting Rod by compound pendulum method.
5. Damped and Undamped Torsional Vibrations of Single and Double Rotor System.
6. Single DOF (Degrees of Freedom) of Spring Mass Damper System. (Damped and Undamped Systems).
7. Free and Forced Vibration of Simply Supported Cantilever Beam.
8. Dunkerley Method to Find Fundamental Frequencies.
9. Critical Speed of Shaft.
10. Modal Analysis of Beam.
11. Cam Analysis of Cams.
12. Any Experiment explaining dynamic aspects of mechanical systems.

Additional Experiments Suggested

1. Determination of Moment of Inertia of Flywheel.
2. Experiment with Bifilar System.

Demonstration Experiments (Can't be allocated in final exams)

1. Velocity Ratios of Simple, Compound, Epicyclic and Differential Gear Trains.
2. Virtual Lab Experiment I – Governors.
3. Virtual Lab Experiment II – Natural Frequency of Cantilever beam.

Note: Minimum ten experiments should be conducted in the semester.

Suggested Reading:

1. S.S. Rattan, Theory of Machines, Tata McGraw Hill, 2010
2. John J.Uicker, J r. G o r d o n, R.Pennock, Joseph E.Shigley, Theory of Machines and Mechanisms, Oxford University Press, 2003.
3. Lab manual supplied by department.

Course Code	Course Title						Core/Elective
PC593ME	**Fluid mechanics & Hydraulic machines laboratory**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	-	-	-	**2**	**25**	**50**	**1**

Course Objectives

Students able to understand

1. **the working of pumps of different kinds and their behaviour.**
2. **the working of turbines of different kinds and their behaviour.**
3. **the theory of working of various flow measuring devices and their utility in industry.**

Course Outcomes

Aftercompleting this course, thestudentwillbe ableto:

1. Practice and experiment on different types of turbines and analyse their performance at rated and off design conditions.
2. Investigate through experimentation different types of pump models and estimate their performance.
3. Apply the priniciple of different flow measuring instruments and their adoptability to the industry.
4. Develop the hydraulic circuits to cater the needs of the industry.

List of Experiments:

1. **Performance and characteristic curves of Self Priming pump**
2. **Performance and characteristic curves of Centrifugal/ Submergible pump**
3. **Performance and characteristic curves of Reciprocating pump**
4. **Performance and characteristic curves of Gear pump**
5. **Impact of Jets on Vanes**
6. **Performance and characteristic curves of Pelton Wheel**
7. **Performance and characteristic curves of Francis Turbine**
8. **Performance and characteristic curves of Kaplan Turbine**
9. **To determine coefficient of discharge of venturi meter**
10. **To determine coefficient of discharge of orifice meter**
11. **Study of Hydraulic Circuits**
12. **Study of pneumatic Circuits**

Course Code	Course Title						Core/Elective
PC601ME	MACHINE DESIGN						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
DMM	3	--	--	--	30	70	3

Course Objectives:

- Importance of helical coil springs and leaf springs in mechanical systems
- Understand the design of gears such as spur, Helical and bevelgears
- How to apply design concepts in bearing design
- Importance of design procedure in designing IC engine components
- Utilization of curved beams on mechanical components

Course Outcomes:

- Analyze helical coil springs and leaf springs for mechanical systems
- Evaluate kinematic transmission systems using gears
- Select bearing system for specific applications
- Design various IC engine components
- Determine load carrying capacity of curved beams

Note: Standard Design data book is allowed in University exam.

UNIT-I

Mechanical Springs: function of springs, Types of springs and materials used. Design of helical coil springs based on strength deflection and energy considerations. End preparation of coil springs, Design for fluctuating loads. Principles of limit design, Concentric springs

Leaf Springs: Stresses and Deflection.Nipping of Leaf springs

UNIT-II

Gears: Types of gears and materials used. Standards for gear specifications. design of spur gears, Helical and Bevel Gears basedstrength criterion -Lewis equation, Wear considerations, dynamic tooth load, Types of gear tooth failure and preventive measures.

UNIT-III

Bearings: Materials used for Bearings. Classification of Bearings. Viscosity of Lubricants Theory of Hydrostatic and Hydrodynamic lubrication. Design of sliding contact bearings - for axial and thrust loads

Rolling Contact Bearings: Different types of rolling element bearings and their constructional details.Static and Dynamic load carrying capacity, Load-life relationship, Design of deep groove ball bearing and roller bearing only, Design for cyclic loads,

UNIT-IV

I.C. Engine Parts: Design of piston, connecting rod and crank shafts. Design of Flywheels for I.C. Engines and Presses

UNIT-V

Curved beams: Theory of bending of members with initial curvature - rectangular, circular and Trapezoidal sections. Design of crane Hooks, Machine frames and C-clamps.

Design of chain drives: types of chain drives, polygonal effect, power rating of roller chains, design of roller and bush type chain, silent chain.

Suggested Reading:

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw-Hill Publ, 3rd Edn. 2010.
2. J.E. Shigley & Charles R. Mischke "Mechanical Engineering Design", Tata McGraw-Hill.,6th ed.2010.
3. P. Kannaiah, Machine Design, Sci-Tech Publ., 2009.
4. P.C. Sharma & D.K. Aggarwal, "Machine Design", S.K. Kataria & Sons, 10th edn, 2003
5. V. B. Bhandari, "Design Data Book " 2nd edition, ", Tata McGraw-Hill Publ, 2019

Note : Solution of Numerical problems using Design data book should be practiced.

Course Code	Course Title	Core/Elective

PC602ME	METROLOGY & INSTRUMENTATION						Core
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- To familiarize with Limits & fits, I.S.O. system and the instruments used to measure these limits.
- To have knowledge of various precision linear and angular measuring instruments.
- To learn the importance of form and how to measure form errors.
- To understand the working principles of various instruments used for the measurement of strain, forces, pressure, temperature and vibrations.

Course Outcomes

After completing this course, the student will be able to:

6. To understand limits, fits and tolerances and their applications. Linear and angular measurements and measuring instruments.
7. To understand the design of limit gauges, evaluate roughness and its measurement.
8. To understand basic measuring system, static and dynamic characteristics of instruments
9. To understand various principles to measure pressure, temperature, displacement, force, torque and vibrations.

UNIT – I

Introduction to Limits, Fits,Tolerances as per ISO, types of interchangeability and limit gauges.Taylor's Principle of guage design, Uses of Plug, Ring and Snap gauges. Introduction to Linear and Angular measurements – Slip gauges and End bars – Gauge materials, Different types of Micrometers, Height gauges Tomlinson gauges. Precision polygon, Sine bar, Auto collimator**.**

UNIT – II

Comparators: Dial indicators, Mechanism of Dial indicators, Mechanical comparators, Pneumatic comparators, Optical comparators, Electrical comparators, Tool maker's Microscope and its applications. Measurement of Straightness and Flatness Roundness measurement with bench centers and talyround.

UNIT-III

Introduction to Surface Roughness Measurements, Profilometer, Taylor Hobson Talysurf. Application of Thread metrology - 2 wire and 3 wire methods, Gear measurement - Gear tooth thickness, Parkinson gear tester, General geometric tests for testing machine tools – Lathe, drill and Mill.

UNIT –IV

Introduction to Elements of instrumentation - Static and Dynamic characteristics, Types of errors, Transducers, LVDT, Strain measurement -Wire and foil type resistance strain gauges. Rosette Gauges,Bonding procedure Lead resistance compensation. Proving ring, Strain gauge load cells, measurement of axial load and torsion by strain gauges, Piezo-electric load cell.

UNIT – V

Introduction to Seismic Transducers -displacement and acceleration measurement, Pressure measurement -Bourdon pressure gauge, pirani gauge. Temperature measurement by thermo couples and its law.Types of materials used in thermocouples Protection tubes. Extension wire- Series and parallel circuit's compensation.

Suggested Readings:

1. I.C. Gupta – "Engineering metrology", Dhanpat Rai Publications, New Delhi.
2. Rega Rajendra, "Principles of Engineering Metrology", Jaico Publishing House, Mumbai.
3. RK Jain, "Engineering Metrology", Khanna Publications, 1996.
4. Doeblin,"Measurement Systems Application and Design", Tata Mc¬Graw Hill,5th ed., 2004.
5. Beckwith, Buck, Lienhard, Mechanical Measurements, Paerson education india.
6. P. Donald Echman, "Industrial Instrumentation", John Wiley and Sons, 1996.
7. Hume, "Engineering Metrology", Kalyani Publications, 1985.

Course Code	Course Title						Core/Elective
PC603ME	FINITE ELEMENT ANALYSIS						Core
Prerequisite	Contact Hours Per Week				CIE	SEE	Credits
	L	T	D	P			
EM, MOM, HT	3	-	-	-	30	70	3

Course Objectives:

1. Equip the students with the Finite Element Analysis fundamentals and formulations
2. Enable the students to formulate the axial, truss, beam and 2d problems
3. Enable the students to formulate the heat conduction and dynamics problems
4. Able to understand use of numerical integration and Gaussian quadrature
5. Enable the students to perform engineering simulations using FE software (ANSYS)

Course Outcomes:

1. Summarize basic equations of elasticity and formulate finite element modeling of one dimensional element using Potential energy approach.
2. Formulate finite element modeling of truss and frame elements along with the concepts of transformation from local to global matrices.
3. Interpolate Hermitian shape function of beam element in natural coordinate system.
4. Develop stiffness matrix for a plane stress & plane strain conditions on a CST, Axisymmetric elements by interpolating shape functions in natural coordinate system.
5. Formulate finite element model to steady state heat transfer analysis using one & two dimensional elements.
6. Formulate mass and stiffness matrices of 1D & beam elements to establish Eigen values &Eigen vectors using Lagarangian and Hamilton principles.

UNIT-I

Introduction to Finite Element Method for solving field problems, Stress and Equilibrium, Boundary conditions, Strain, Displacement, Stress-Strain relations.

One dimensional problems: Finite element modeling coordinates and shapes functions, Potential Energy approach: Assembly of Global stiffness matrix and load vector, Finite element equations, Treatment of boundary conditions, Galerkin's approach, Quadratic shape functions.

UNIT-II

Analysis of trusses and frames: Element stiffness matrix for a truss member, Analysis of plane truss with two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node, Analysis of Beams: Element stiffness matrix for two nodes (two degrees of freedom per node).

UNIT-III

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Finite element modeling of axi-symmetric solids subjected to axi-symmetric loading with triangular elements.

UNIT-IV

Two dimensional four noded iso-parametric elements and numerical integration. Steady state heat transfer analysis: One dimensional analysis of a fin and two dimensional analysis of thin plate, Analysis of circular shaft subjected to torsion.

UNIT-V

Dynamic Analysis: Formulation of finite element model, element matrices, Evaluation of Eigen values and Eigen vectors for a stepped bar and a beam, Time dependent field problems: Application to one dimensional heat flow in a rod **Convergence requirements.** Introduction to Finite Element Analysis Software.

Suggested Reading:

1. G.Ramamurthy, Applied Finite Element Analysis, I.K. International Publishing House Pvt.Ltd., New Delhi, 2009.
2. Tirupathi R, Chandraputla and Ashok D Belagundu, Introduction to Finite Elements in Engineering, Prcatice Hall of India,1997.
3. Rao S S, The Finite Element Method in Engineering, Pergamon Press, 1989.

4. Segerlind L J, Applied Finite Element Analysis, Wiley Eastern, 1984.
5. Reddy JN, An Introduction to Finite Element Method, McGraw-Hill, 1984.

Course Code	Course Title	Core/Elective

PE611ME	**CAD/CAM**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives:

- ❖ To introduce the concepts of CAD and advanced modeling techniques
- ❖ To help the students in understanding the functioning of computer numerical control machine tools and also in writing programs for operating this machines.
- ❖ To help the student in understanding advanced manufacturing concepts like Group technology, flexible manufacturing systems, Computer aided Process Planning, Computer aided quality control, Artificial Intelligence etc.

Course Outcomes:

The Students will be able to

- ➢ Understand the fundamental applications of computer in design, manufacturing and geometric transformation techniques in CAD
- ➢ Develop mathematical Model for curves, surfaces, solid models and understand the fundamental concepts of Finite Element Analysis
- ➢ Write CNC Part program for manufacturing components
- ➢ Understand the concepts of Machining Centres, adaptive control and as well as fundamentals knowledge of robotics
- ➢ Understand the working of various components of an modern manufacturing systems

Unit-I

CAD Fundamentals, Product life cycle in conventional and computer based manufacturing system, Hardware integration and networking. CAD Software: Definitions of system software and application software. Graphic Standards and Exchange Formats. CAD database and structure. Automatic 2-D facilities such as Fillets, Chamfers, Hatching, Dimensioning, Editing, Windowing & Zooming. 2-D & 3-D Geometric Transformations.

Unit-II

Geometric modeling: 3-D wire frame modeling: wire frame entities and their definitions, Interpolation and approximation of curves, synthetic curves and curve fitting. Definitions of cubic, Bezier, and B-spline curves.

Surface modeling: Definitions of basic surfaces, surface of revolution, blends, intersection, and Cubic, Bezier, B-spline surfaces.

Solid Modeling: Solid entities, Boolean operations, B-rep and C-rep approaches. Feature based modeling: Concepts and applications, Assembly modeling.

Finite element modeling: Introduction, modeling, Meshing, Characteristics of different elements, different solvers and post processing.

Unit-III

Numerical Control of machine Tools: Features and elements of NC. Positional, paraxial and contouring types. Definitions of axes, punched type, formats of tape preparation. Definitions of interpolation, post-processor, preparatory and miscellaneous functions, canned cycles, tool length and cutter radius compensation. Manual and computer aided part programming (APT) for simple components. Programming with MACROS.

Unit-IV

Computer Control in NC and Robots: Machining centers, CMC, DNC and adaptive control systems. Their types, typical configurations and relative features. Industrial Robots: Classification based on manipulator configurations, relative characteristics, Online and offline programming methods, controls and drives, applications.

Unit-V

Group Technology: Organization, G.T. layout, part classification and coding, CAPP: Variant and Generative approaches and their relative features. Computer Aided Quality Control: Computer in quality control, Contact and non contact inspection, optical and non optical computer aided testing. Basic concepts of FMS, Experts systems. Artificial intelligence, CAD/CAM integration, Introduction to 3D Printing: Process chain, Classification , description about SLA, SLS and FDM processes.

Suggested Reading:

1. Ibrahim Zeid, "CAD/CAM, theory and practice", McGraw Hill Inc, N.Y.1991.
2. Grover, MP and Zimmers E.W., "CAD/CAM", Prenctice Hall of India 1989.
3. Rao P.N., Tiwari N.K., Kundra T.K., "Computer Aided Manufacturing", Tata McGraw Hill, New Delhi, 1993.
4. Radhakrishnan. P, Subramanyan. S, Raju. V, "CAD/CAM/CIM", New Age international (P) Ltd., 2nd Edn., 2004.

Course Code	Course Title						Core/Elective
PE612ME	**AUTOMOBILE ENGINEERING**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

The objectives of this course is to impart knowledge of

- Understand the Working of Fuel, Ignition, and cooling Systems.
- Understand the Working of Lubrication and Electrical Systems
- Understand the Working of Suspension, Steering and Braking Systems.
- Understand the Working of Power Transmission.
- Understand the Necessity of Pollution Control and Maintenance.

Course Outcomes

After completing this course, the student will be able to:

1. Generalize the different types of automobiles, list the engine components, describe the functioning of IC engines and classify the fuel supply system for S.I and C.I engines
2. Differentiate the types of lubrication system; identify different lubrication and cooling systems used in vehicles. Classify ignition system and describe the functioning of battery and automobile air conditioning system.
3. List the salient features of different steering mechanisms, describe the importance of wheel alignment and wheel balancing, describe the importance of different suspension systems and shock absorbers used in an automobile
4. Identify different components in power transmission system design a system, components, or process to meet desired needs with in realistic constrains such as economic, environmental, health and safety, describe about braking system
5. Adapt techniques, skills and modern engineering tools necessary to control the pollution, record the automobile parts maintenance, design and build components and system to reduce pollution of automobile vehicles

UNIT – I

Types of automobiles: Normal, Hybrid and Hydrogen fuel vehicles. Engine location and its components, chassis layout, crank shaft proportion, firing order, piston and piston rings, cylinder liners, valves and operation mechanism, inlet and exhaust manifolds, carburetion and fuel injection system, mechanical fuel injection system & electronic fuel injection system.

UNIT – II

Lubricating systems: Wet sump, dry sump and petrol systems, and Cooling systems: Water pumps, radiators, thermostat control anti freezing compounds. Types of Ignition systems, modern ignition systems, types of batteries and charging systems, starting motors, lighting and electrical accessories, automobile air-conditioning.

UNIT-III

Steering systems: Linkage arrangements and its components modified Ackerman linkage, wheel alignment, caster and camber. Rack and pinion assembly – recent trends Wheel and tyres: Tyre construction, specification. Tyre wear and causes, wheel balancing, types of suspension system, independent suspension coil and leaf springs, torsion bar, shock absorbers.

UNIT –IV

Power Train: Clutches, gear and gearbox manual, semi-automatic and automatic gearboxes. Torque converter, propeller shaft, universal coupling differential, four-wheel drive system.Brake systems: Description and operation of hydraulic brake, leading and trailing shoe layout, disc brakes, master cylinder, hand brake linkage, recent trends.

UNIT – V

Maintenance: Pollution control, trouble shooting and servicing procedure overhauling, engine tune up, tools and equipment for repair and overhaul, testing equipment, pollution control technologies used for petrol and diesel engines, types and study of catalytic converters, Euro norms 2 & 3 and Bharat Norms – recent trends.

Suggested Readings:

1. Crouse & Anglin, 'Automotive Mechanics' Tata McGraw Hill, Publishing Co., Ltd., New Delhi, Tenth edition - 2004..
2. Kirpal Singh, "Automobile Engineering", Vol I & II Standard Publishers, Delhi.
3. Joseph Heitner, 'Automotive Mechanics', Affiliated East West Pvt., Ltd.,
4. C.P. Nakra, "Basic Automobile Engineering", Dhanpat Rai Publishing Co.(P) Ltd., New Delhi, 2003

Course Code	Course Title						Core/Elective
PE613ME	**MODERN MACHINING AND FORMING METHODS**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

To know the importance of unconventional machining and forming processes.

To learn the working principle of various modern machining and forming processes.

To understand the advantages, limitations and applications of various modern machining and forming processes.

To know the relationship between process parameters and performance of various processes.

To know the suitability of processes for various engineering materials and applications.

Course Outcomes:

Students will be able to:

- Understand the evolution, classification and need of nontraditional machining technology in modern manufacturing
- Understand the principle, description, the parametric effect on process performance and material removal mechanics of USM, AJM, WJM and AWJM processes.
- Understand the principle, description, the parametric effect on process performance and material removal mechanics of EDM, EDG, ECM and CHM processes.
- Understand the principle, description, the parametric effect on process performance and material removal mechanics of LBM, EBM, PAM and Ion machining processes.
- Compare conventional & high energy rate forming methods
- Understand the principle, working and applications of various types of high energy rate forming methods.

UNIT-I

Introduction: Need for nontraditional machining processes, selection, classification & comparative study of different processes; **Ultrasonic Machining (USM):** Introduction, process description, abrasive slurry, Abrasive materials and their characteristics. Functions of liquid medium in slurry, Types of Transducers, effect of process parameters, applications and limitations; **Abrasive Jet Machining (AJM):** Principle of operation, process details, process variables and their effect on MRR and accuracy. Equation for MRR Advantages, disadvantages and applications; **Water Jet Machining (WJM):** Schematic diagram, equipment used, advantages and applications; **Abrasive Water Jet Machining (AWJM):** Schematic diagram, equipment used, advantages and applications.

UNIT-II

Electro Discharge Machining (EDM): Process description with schematic diagram, process parameters, functions and characteristics of dielectric medium, dielectric fluids, over cut and side taper' Flushing, Mechanism of metal removal, crater volume, types of power supply circuits, mathematical analysis of metal removal rate (MRR), characteristics of spark eroded surfaces, advantages, disadvantages and applications.

Wire EDM: Process description and applications; **Electro Discharge Grinding:** Process description and applications; **Electro-Chemical Machining (ECM):** Schematic of the process parameters, function and characteristics of electrolyte, chemistry of the process, Equation for specific MRR and electrode feed rate, advantages, limitations and applications; **Electro Chemical Grinding:** Process description and applications.

UNIT-III

LASER Beam Machining (LBM): Principle of LASER Beam production, materials used, thermal analysis of the process, process parameters, equations for power density and machining rate, advantages, limitations and applications; **Plasma Arc Machining (PAM):** Introduction equipment used, process description and parameters, types of plasma arc - Transferred arc and non transferred arc; advantages, disadvantages and applications; **Electron Beam Machining (EBM):** Schematic of the process, process parameters, principle of production of Electron beam, equipment used, Advantages, disadvantages and applications; **Ion Etching:** Process description and applications.

UNIT-IV

High Energy Rate Forming (HERF): Introduction, comparison of conventional & high energy rate forming methods. Types of high energy rate forming methods; **Explosive Forming:** principle, Explosive materials, types of explosive forming - standoff operation and contact operation, advantages, disadvantages and applications; **Electro-Hydraulic forming (EHF):** Schematic of the process description and its applications; **Electro-Magnetic Forming (EMF):** Schematic of the process description and its applications; **Rubber Pad Forming:** Principle, process details and its types; Guerin, wheel on, Marfoming and Hydro forming processes and applications.

UNIT-V

Stretch Forming: Introduction, types of stretch forming - stretch draw forming, rotary stretch forming or stretch wrapping, compression forming and radial draw forming, Stretch forming equipment and accessories, accuracy and surface finish, process variables, limitations and applications; **Tube spinning:** Introduction, methods of tube spinning - backward spinning, Forward spinning; machines and tools used, machine variables - speeds and feeds; effect of tube spinning on work metal properties and applications; **Hydrostatic Forming:** Process principle, description and applications; **Water Hammer Forming (WHF):** Schematic diagram of the process, principle of operation, process variables, work materials, process limitations and applications.

Suggested Reading:

1. P.K.Mishra "Non Traditional Machining processes" Narosa Publications, New Delhi, 2001.
2. V.K Jain "Advanced Machining Processes" Allied Publishers, Hyderabad.
3. Davies and Austin, Developments in High Speed Metal Forming, The Machinery Publishing Co. Ltd., 1985.
4. HMT Production Technology, Tata McGraw Hill Publications, 1995.

THERMAL TURBO MACHINES

PE621ME

Instruction: 3 periods per week *Duration of SEE: 3 hours*

CIE: 30 marks *SEE: 70 marks*

Credits : 3

Objectives:

1.	Understand isentropic flow for variable areas and relations
2.	Understand and apply fanno flow, Rayleigh flow and shock flow.
3.	Understand centrifugal and axial flow compressor with velocity triangles
4.	Understand and analyze impulse and reaction steam turbines with velocity triangles
5.	Understand and analyze gas turbines and rocket propulsion.

Outcomes:

1.	Analyze situations of Thermal gradients in Turbo machines and apply the situation of fluid flow analysis with energy conversion principles for work transfer.
2.	Develop knowledge about working principles of work absorption and work producing situations
3.	Understand applications of Thermodynamics with fluid flow behavior and compressibility effects
4.	Attain knowledge of Power production using External combustion engines, with methods of improving efficiencies
5.	Demonstrate the learnt fundamentals in applying for real time situations such as undertaking final dissertation projects on Thermal turbo Machines and power plants with knowledge of International standards and testing.
6.	Establish and compute one dimensional thermodynamic analysis of Compressors, Turbines (both for air & Vapour working fluids) and analyzing using velocity triangles for single and multi stages.

Unit-I

Introduction to compressible flows: Speed of propagation of pressure waves, Mach number, Acoustic velocity and Mach cone, limits of compressibility, pressure field due to a moving source of disturbance, one dimensional compressible flow.

Isentropic flow with variable area, Mach number variation, Area ratio as function of Mach number, flow through nozzles and diffusers.

Flow in constant area ducts with friction-Fanno flow, variation of flow properties, variation of Mach number with duct length, isothermal flow with friction.

Unit-II:

Flow in constant area duct with Heat Transfer, -The Rayleigh liner, Rayleigh flow relations, variation of flow properties, Maximum heat transfer.

Flow with Shock Waves-Development of Normal Shock waves, governing equations, Prandtl -Meyer relation, Rankine-Hugoniot equations, Stagnation pressure ratio across shock.

Unit-III

Blade nomenclature of an aerofoil, Rotodynamic compressors: Introduction and general

classification, Comparison of Reciprocating and Rotary compressors, Positive displacement Rotary compressors, Flow through rotary compressors. Static and total head quantities, Thermodynamic cycles and work done,calculation of various efficiencies. Velocity diagrams and prewhirl. Euler equation for energy transfer between fluid and rotor, Analysis of Centrifugal compressors and analysis of axial flow compressors, Chocking, Surging and Stalling.

Unit-IV

Steam Turbines: Classification, flow over blades, pressure velocity variations, Compounding of steam turbines- pressure compounding, velocity compounding and pressure-velocity compounding, Impulse turbine with several blade rings, Nozzle efficiency, Blade efficiency and Gross stageefficiency of Impulse turbine, Velocity diagrams for Impulse turbine-De Laval Turbine, blade efficiency of Impulse turbine, Optimum blade speed ratio, Maximum work done and blade efficiency of Impulse turbine, Degree of reaction of Reaction turbine, Parson Reaction turbine, Velocity diagram for Parson Reaction turbine, blade efficiency of Parson Reaction turbine, Maximum work done and blade efficiency of Parson Reaction turbine, Height of blades of Reaction turbine, Balancing of End thrust.

Unit-V

Gas Turbines: Applications and Classification of Gas Turbines- constant pressure and constant volume gas turbines, Joule cycle-configuration diagram and temp-entropy diagram, Thermal efficiency of Joules cycle, Maximum pressure ratio in terms of temperature ratio, optimum pressure ratio for maximum work output with and without considering machine efficiencies, Improvement of gas turbine plant performance- Inter-cooling, Reheating and Regeneration. Simple Problems on Joule cycle.

Air Craft Propulsion: Air craft engine types, air craft propulsion theory, Turbo jet engines, Ramjet engines, Pulse jet engines, Rocket Propulsion: Types of Propellants, Types of Rocket engines, Rocket propulsion theory-Rocket applications.

Suggested Reading:

1. Yahya S M, *Fundamentals of Compressible Flow*, New Age International Publishers, Third Edition, 2007.
2. Mathur ML, & Mehta F S, *Thermal Engineering*, Jain Brothers, New Delhi, 2003.
3. Dennis G Shepherd, *Aerospace Propulsion*, Elsevier Publishing Company, New York, 1995.
4. CohenH Rogers G F C, SaravanaMutto H I H, *Gas Turbine Theory*, Longman 5th Edition, New York, 2004.
5. Ganeshan V, *Gas Turbines*, Tata Me Graw Hills, New Delhi, 2003
6. Yadav, R *Steam and Gas Turbines*, Central Publishing House Ltd, Alllahabad, 2003.

PRODUCTION AND OPERATIONS MANAGEMENT

PE622ME

Instruction: 3 periods per week *Duration of SEE: 3 hours*

CIE: 30 marks *SEE: 70 marks*

Credits : 3

Objectives:

1. To understand the concept of Production & Operations Management.
2. To understand role of work study and work measurement in Industry.
3. To learn use of forecasting and various methods of it.
4. To understand importance Aggregate planning, Materials Requirement Planning for Industry.
5. To understand Project Management approaches in completion of Project.

Outcomes:

1. Explain various types of Production Systems, develop suitable layout for a given plant
2. Develop various methods for work study and apply suitable Recording techniques. Develop standard procedures and time for the operations.
3. Explain necessity of Forecasting and various methods of it. Develop suitable quantitative forecasting technique for the given past data. Compare accuracy of models in connection with forecast errors.
4. Explain Aggregate planning & Mater scheduling, Materials Requirement Planning Processes. Develop quantitative models for Material requirement and resources based on time span.
5. Elaborate the usages of PERT/CPM techniques for a give project and develop suitable quantitative model for the project in successful competition by identifying the time constraints for start and endof process activities.

Unit-I
Production & Operations Management: Introduction, Types of production Systems. Job shop, Batch, Flow shop. **Plant location and layout**: Factors affecting plant location, Break even analysis, plant layout objectives, Types of layouts, merits and demerits.
Unit-II:
Work Study: Introduction to method study, Steps in method study, Recording techniques- Flow process chart, String diagram, Therbligs, Principles of motion economy. **Work measurement**: Stop watch time study, Standard time calculation. Work sampling-procedure, applications, advantages and disadvantages, Wages and incentives, types of incentive plans.

Unit-III
Forecasting: Introduction, Forecasting objectives and uses, demand patterns, Qualitative models Market survey, Delphi Tech, Quantitative models, Moving average, Weighted moving average, Simple exponential smoothing, trend adjusted exponential smoothing, Least square method, Simple regression, multiple regression. **Forecast errors:** Mean absolute Deviation (MAD), Mean Square Error (MSE), Mean Forecast Error(MFE), Mean absolute percentage error (MAPE).
Unit-IV
Aggregate Planning and Master Scheduling: Introduction, objectives of aggregate planning, Cost in aggregate planning, Strategies in aggregate planning, Master production scheduling. **Materials Requirement Planning MRP 1**: Importance of MRP, MRP system inputs and outputs, MRP calculations **Manufacturing Resource Planning MRP 2 & Enterprise Resource Planning (ERP):** Features of ERP packages like SAP, BANN, People soft etc.,
Unit-V
Project Management: Project management: Network fundamentals, difference between PERT/CPM Scheduling the activities. Fulkerson's rule. Earliest and latest times. Determination of ES and EF in the forward path. LS and LF in backward path. Determination of critical path. Free float, independent float, Total float, Program evaluation and review technique, crashing of network.

Suggested Reading:

1. Joseph Monk, *Operations Management*, TMH Publishers, New Delhi, 2004.
2. Buffa Elwood S, *Modern Production / Operations Management*, John Wiley Publishers, Singapore, 2002.
3. Everett E Adam, Jr and Ronald J. Ebert, *Production and Operations Management – Concepts, Models and Behaviour*, 5th Ed. 1998, (EEE), Prentice Hall of India(P) Ltd., New Delhi.
4. Panneer Selvam R, "*Operations Research*", Second Edition, PHI Learning Pvt. Ltd. New Delhi, 2006.
5. S.D. Sharma, "*Operations Research*", Kedarnnath, Ramnath & Co., Meerut, 2009.

DESIGN FOR MANUFACTURE

PE623ME

Instruction: 3 periods per week *Duration of SEE: 3 hours*

CIE: 30 marks *SEE: 70 marks*

Credits : 3

Objectives:

1. To understand and applications of the basics and working principles of manufacturing.
2. To grasp the knowledge of basic mechanical components and design the simple components.
3. To learn the knowledge of design of different types of machine components to meet varied functional and operational requirements.

Outcomes:

1. To recognize the strength and mechanical factors of metals and non metals.
2. To understand the design of metallic components and its processes.
3. To understand the advanced design of metallic and non metallic components.
4. To recognize the design of non metallic assembled mechanical components.
5. To understand the varies assemblies and part design with automation.

Unit-I
Introduction: General design principles for manufacturability, strength and mechanical factors, mechanisms selection, evaluation method, geometrical tolerances, tolerances control and utilization. Economic Use of Raw Materials: Ferrous steel, hot rolled steel, cold finished steel, stainless steel,non ferrous materials aluminium, copper, brass, non metallic materials, plastics, rubber and composites.
Unit-II:
Metallic components design: metal extrusion. Metal stamping , , spring and wire forms, spun metal parts, cold headed parts, tube and section bends, rolled formed parts, power metal parts, forging electro forming parts, special forming methods.
Unit-III
Metallic components design: Turned parts, machined round holes, drilled parts and milled parts. Planned shaped and slotted parts, screw threaded contoured and internal ground parts, center less ground, Electrical discharged, electro chemical and advanced machine parts.
Unit-IV
Non metallic components design: Sand cast , die cast, investment cast and other cast products, injection moulded and rotational moulded parts, blow moulded, welded plastic articles, ceramics.
Unit-V
Assembled parts design: bolted connections, welded parts, arc, resistance , brazed and soldered parts, gear box assembly, bearing assembly, flanged connections, press fitted connections, surface finishing, plated parts, Heat treated parts, NC machining , Group technology, low cost automation,

computer aided manufacture, product design requirements.

Suggested Reading:

1	*Hand book of product design for manufacturing by James G.Bralla, MC Graw Hill Co., 1986.*
2	*Knowledge based design for manufacture by K.G. Swift, Kogan page limited, 1987.*
3	*Design for manufacturability by David M. Anderson, Productivity Press, 2014.*
4	*1. Design for Manufacturability Handbook, McGraw-Hill Handbooks,1998.*
5	*2. Product Design for Manufacture and Assembly by Geoffrey Boothroyd, CNC Press, 2010*

Course Code	Course Title						Core / Elective
OE611ME	**INDUSTRIAL ROBOTICS**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**0**	**0**	**0**	**30**	**70**	**3**

Course Objectives

- To familiarize the student with the anatomy of robot and their applications.
- To provide knowledge about various kinds of end effectorsusage.
- To equip the students with information about various sensors used in industrial robots.
- To make the student understand the importance of spatial transformation of robots using forward and inverse kinematics.
- To specify and provide the knowledge of techniques involved in robot vision in industry.
- To equip students with latest robot languages implemented in industrial manipulators.

Course Outcomes

- Able to demonstrate knowledge of the relationship between mechanical structures of industrial robots and their operational workspace characteristics and have an understanding of the functionality and limitations of robot actuators and sensors.
- Able to demonstrate an ability to apply spatial transformation to obtain forward/Inverse kinematics equation of robot manipulators using analytical/numerical/simulation tools.
- Able to apply knowledge and choose the best & economically suitable sensors/end effectors required for specific applications.
- Able to understand the importance of robot vision and apply the learnt techniques to get the required information from input images.
- Able to design and develop a industrial robot for a given purpose economically.
- Appreciate the current state and potential for robotics in new application areas.

UNIT – I

Introduction to Robotics: Basic structure of Robots. Degree of freedom of Robots, Work envelope, Classification of Robots based on Drive Technology, Work-Envelope and motion control methods. Application of Robots in Industry, Repeatability, Precision and Accuracy as applied to Robots, Specifications of robots used for various applications. End effectors, Grippers: Mechanical grippers, pneumatic and hydraulic grippers, magnetic grippers, vacuum grippers, RCC grippers, Two fingered and three fingered grippers, internal grippers and external grippers, Selection and design considerations.

UNIT – II

Requirements of a Sensor: Principles and Applications of the following types of sensors- Position of sensors (Piezo electric sensor, LVDT, Resolvers, Optical encoders, Pneumatic position sensors), Range sensors (Triangulation principle, Structured, Lighting approach, Time of flight range finders, Laser range meters), Proximity sensors (Inductive, Hall effect, Capacitive, Ultrasonic and Optical proximity sensors), Touch sensors (Binary sensors, Analog sensors), Wrist Sensors, Compliance Sensors, Slip Sensors.

UNIT – III

Kinematic Analysis of Robots: Rotation matrix. Homogeneous transformation matrix, Denavit&Hartenberg representation, Euler and RPY angles representation. Representation of absolute position and orientation in terms of joint parameters, Direct Kinematics of manipulators, Inverse kinematics of Robot arm for position and orientation. Redundancy in Robots, Static force analysis

UNIT-IV

Introduction to Techniques used in Robot Vision: Image acquisition, illumination techniques, imaging geometry, basic relationship pixels, preprocessing, segmentation & description of 3-dimensional structures, their recognition and interpretation. Types of Camera, frame grabbing, sensing and digitizing image data, Signal conversion, Image Storage, Lighting techniques, Image processing and analysis, Data reduction, Segmentation, Feature extraction, Object recognition, and various algorithms, Applications, Inspection, identification, visual serving and navigation.

UNIT – V

Robot Programming Languages: Characteristics of robot level languages, task level languages. Teach pendant programming, Lead through programming, Robot programming languages, VAL programming, Motion commands, Sensor commands. End effecter commands, Simple programs. RGV, AGV, Implementation of robots in industries, various steps, Safety considerations for robot operations. Economic analysis of robots, Pay back method, EUAC method and Rate of return method

Suggested Readings:

1. Groover M P, "**Industrial Robotics"**, McGraw Hill Publications,1999.
2. Fu. K.S., GonZalez R.C., Lee C.S.G. "**Robotics, Control-sensing vision and Intelligence**", McGraw Hill, Int. Ed.,1987.
3. Spong and Vidyasagar, "**Robot Dynamics & Control**", John Wiley and Sons,Ed.,1990.
4. Mittal and Nagrath, "**Industrial Robotics**", Tata McGraw Hill Publications,2004.
5. Saha&Subirkumarsaha, '**Robotics'**, TMH,India.

Course Code	Course Title						Core/Elective
PC691ME	**METROLOGY & MACHINE TOOLS LAB**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To have knowledge of various precision measuring instruments.
- To familiarise machining and metal cutting operations.

Course Outcomes

After completing this course, the student will be able to:

1. Select and apply the knowledge of measuring tools for external, internal and angular measurements for promoting the qualitative production management.
2. Adapt the principles of optical measurements in measurement of screw and gear profiles.
3. Choose and practice the appropriate methods of force measuring devices principles for required situation.
4. Demonstrate the need of machine alignment test for qualitative production.
5. Practice calibration principles for maintaining the required precision of instruments / tools.
6. Select and practice the methods of temperature measurement.
7. Select cutting tool materials and tool geometries along with appropriate cutting conditions for different work materials and grind the cutting tools to the required geometry.
8. Recognize and summarize the features and applications of various machine tools like Lathe, Milling, Drilling, Grinding, Shaping, Slotting etc.

List of Experiments:

A) Metrology & Instrumentation:

1. Measurement with inside, outside and depth micrometers, Vernier calipers and Height gauges.
2. Measurement of roundness errors with Bench Centres, V-block and dial guage.
3. Measurement of Linear and Angular dimensions with Tool Maker's Microscope: Flat specimens.Plain cylindrical specimens with centers and threaded components.
4. Measurement of angles with Sinebar, Bevel protractor and Precision level.
5. Measurement with Dial Indicator / Electrical Comparator / Mechanical Comparator / Dial Bore Gauge / Snap Gauge/Plug gauges.
6. Calibration and Force measurement with Strain gauge type load cell/Proving Ring/spring type sensor

B) Machining Operations:

7. Thread cutting exercise on lathe machine as single start and multi start threads.
8. Typical exercises on lathe machine(Turning,Step turning,Facin,Parting off &Taper turning).
9. Typical exercises on shaper, cylindrical grinding machine.
10. Exercise of simple gear manufacturing on milling machine.
11. Production of threads with taps and threading dies and milling cutters.

C) Metal Cutting:

12. Estimation of shear angle by measuring thickness and length of chips.
13. Measurement of Cutting forces with Lathe tool dynamometer and determination of friction angle and stresses on shear plane and rake plane.
14. Study of geometrical tests on lathe machine.

Note: At least ten experiments should be conducted.

Course Code	Course Title						Core/Elective
PC692ME	Computer Aided Engineering LAB						Core
Prerequisite	**Contact Hours per Week**				**CIE**	**SEE**	**Credits**
	L	**T**	**D**	**P**			
-	-	-	-	2	25	50	1

Course Objectives:

- To introduce fundamentals of the analysis software, its features and applications.
- To learn the basic element types in Finite Element analysis.
- To know the concept of discretization of continuum. Loading conditions and analyze the structure using pre-processor and postprocessor conditions.

Course Outcomes:

- Classify the types of Trusses (Plane Truss & Spatial Truss) and Beams (2D & 3D) with various cross sections to determine Stress, Strains and deflections under static, thermal and combined loading
- Generalized Plane stress, plane strain conditions & axi-symmetric loading on inplane members to predicting the failure behavior and finding the SCF
- Analyse connecting rod with tetrahedron and brick elements, performing static analysis on flat & curved shells to determine stresses, strains with different boundary conditions.
- Predict the natural frequencies and modes shapes using Modal, Harmonic analysis. Also finding the critical load using Buckling analysis
- Simulate steady state heat transfer analysis of chimney, Transient heat transfer of castings, Non linear, Buckling analysis of shells CFD analysis
- Evaluate the stiffness matrix, B matrix and loading matrices of beam in plane/solid elements using MATLAB / Python software

1. Analysis of Plane Truss & Spatial Truss with various cross sections and materials to determine member forces, member strains & stresses, joint deflections under static, thermal and combined loading.
2. 2D & 3D beam analysis with different sections, different materials for different loads (forces and moments with different end supports.
3. 1D, 2D and 3D meshing with different element sizes for different CAD geometry (Proposed Experiment)
4. Static analysis of plates with a hole to determine the deformations, the Stresses to study the failure behavior and SCF.
5. Plane stress, plane strain and axi-symmetric loading on the in plane members with in plane landing to study the stresses and strains.
6. Static analysis of connecting rod with tetrahedron and brick elements
7. Static Analysis of flat and curved shell due to internal pressure and moments to estimate the strains, stresses and reactions forces and moments with different boundary conditions .
8. Buckling analysis of plates, shells and beams to estimate BF and modes.
9. Modal analysis of beams, plates and shells for natural frequencies and mode shapes.

10. Harmonic analysis of a Shaft subjected to periodic force and transient analysis of plate subjected to stepped and ramped loading with varying time .
11. Steady state heat transfer Analysis Cross section of chimney and transient heat transfer analysis of solidification of castings.
12. Non linear analysis of cantilever beam with non-linear materials at tip moment and post Buckling analysis of shells for critical loads
13. Coupled field analysis.
14. Flow analysis of pipe with different fluids/gasses/air for velocity and pressure gradients.
15. Implicit and Explicit Analysis of car with 300m/s (Proposed Experiment)
16. CFD analysis of aerofoil design.
17. CFD analysis of ducts/impeller/fan.
18. CFD analysis of racing car (Proposed Experiment)
19. Use of MATLAB / Python for finding B matrix, stiffness matrix and loading matrices of beam/in plane/solid elements and interfacing with CAE software's .

Note : Any 12 experiments to be conducted