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

Production 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. (Production 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	PC501PE	Machine Tool Design	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	PC502PE	Computer Aided Design and Manufacturing	3	-	-	3	30	70	3	3
LaboratoryCourse										
6	PC591PE	Computer Aided Production Drawing	-	-	2	2	25	50	3	1
7	PC592ME	Dynamics of Machines Lab	-	-	2	2	25	50	3	1
8	PC592PE	Modern Manufacturing and Testing 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. (Production 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	Professional Elective – I	3	-	-	3	30	70	3	3
5	OEC - 1	Open Elective – 1	3	-	-	3	30	70	3	3
6	OEC - 2	Open Elective – 2	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 (OE601ME) : Entrepreneurship (Not for Mechanical / Prod. / Automobile)
Open Elective - 2 (OE602ME) : Industrial Robotics (Not for Mechanical / Prod. / Automobile)

PROFESSIONAL ELECTIVE - I	
PE611PE	Additive Manufacturing Technology
PE612ME	Automobile Engineering

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
PC 501 PE	MACHINE TOOL DESIGN						Core
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
-	3	--	--	--	30	70	3

Course Objectives:

- To understand the basics and working principles of machine tools.
- To grasp and understand the functional and operational requirements of different types of machine tools.
- To learn the knowledge of design of different types of drives and gears to meet varied functional and operational requirements.
- To understand the hydro dynamics mechanism of machine tools.
- To learn the knowledge of hydraulic controls of machine tools.

Course Outcomes:

After completion of the course, the students will able:

- To differentiate between various machines tools & their specifications, recognize the kinematics and its mechanism of the machines.
- To recognize the drives of the machine tools at varies speeds.
- To understand the drives and analysis of the machine tool componants.
- To recognize the varies spindle speeds of machine tool elements.
- To understand the varies hydraulic controls of machine tools.

Unit-1

Classification of machine tools. Mechanisms used for converting rotary to linear motion and intermittent motion. Kinematic structures of machine tools - general purpose, special purpose, automatic screw cutting machines. Basic features of transfer machines. Numerical Control of machine tools, advantages and limitations. Schematic diagrams of NC systems.

Unit-II

Drives of machine tools; selection of range of speeds and feeds. Speed layout in GP, AP and logarithmic progression. Standardization of speeds and feeds. Productivity loss. Selection of highest and lowest speeds, range ratio. Design of ray diagram and structural diagrams for machine tool gear boxes. Determination of number of teeth and module of gears in gear box design. Rules for layout of gear box having sliding clusters. Sliding cluster and clutched drives, Ruppert drive.

Unit-III

Feed gear boxes: Norton and Meander gear boxes. Stepped and step less regulation of speeds.Strength and Rigidity design analysis. Design of beds, frames, Columns and Guide ways.Materials for structures. Methods to improve the rigidity of structures. Overall compliance of machine tool. Thermal effects - functional accuracy of machine tool.

Unit-IV

Spindle units; Spindles of lathe, Drilling, Milling and Grinding machines materials for spindles. Spindle design. Effect of clearance on the rigidity of spindle. Hydro-dynamic and Hydro-static bearings; Requirements of spindle bearings.

Unit-V

Hydraulic controls: various controls used in machine tools. Hydraulic and Pneumatic systems used in machine tools. Positive displacement pumps. Power pack. Relief valves, check valves, flow control valves, multi position direction control valves, Filters, Accumulators. Speed regulation of surface grinding machine. Hydro- copying systems.

Suggested Reading:

1. G C Sen & Bhattacharya, *Principles of machine tools,* New Central Book Agency, Calcutta.
2. N K Mehta, *Machine Tool Design and Numerical Control,* Tata McGraw-Hill Publishing co. Ltd.
3. S.K.Basu, *Design of machine tools*, Allied Publishers
4. S R Majumdar, *Hydraulic Systems- Principles & Maintenance*, Tata Mc.Graw-Hill Publishing Company *Limited; New* Delhi

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
PC502PE	**COMPUTER AIDED DESIGN AND MANUFACTURING**						**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

- Computer aided design and its standards
- Geometric modelling and its types and techniques
- NC machine and Part programming of machining
- Advanced NC machines, Basic exposure to industrial robots and Group Technology
- Importance and significance of CAPP, CAQC, Reverse engineering and Rapid Prototyping

Course Outcomes

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

1. Appraise about the product life cycle and CAD standards. Analyse the geometric transformations.
2. Differentiate the types of geometric modelling and apprehend the application of geometric modelling w.r.t real time applications.
3. Execute the part programming for machining.
4. Identify the working of CNC, DNC, Robots and analyse the applications of GT.
5. Differentiate the various CAPP, CAQC techniques and understand the advancement in CAM technologies i.e. reverse engineering and rapid prototyping.

Unit -I

Fundamentals of CAD: Introduction to CAD and its tools, Product life cycle, sequential and concurrent engineering,Computer Aided Design, Coordinate systems,2D transformations.CAD standards- Graphical Kernel System (GKS), Data exchange standards- IGES, STEPetc.Types of CAD database, various types of network.

Unit –II

Geometric Modeling: Types of geometric modeling. Wireframe modeling -representation of analytic and synthetic curves, Hermite curves, Bezier curves, B-splinecurves, NURBS, Entities of surface modelling, Analytic surface entities andbicubicpatches, Bezier and B-spline surfaces, Solid modelling techniques, CSG and B-rep**.**

UNIT-III

Numerical Control Machine Tools: Features and elements of NC, Positional, paraxial and contouring types. Definitions of axes. 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 Numerical Control: CNC, DNC and Adaptive control systems. Machining centers.
Industrial Robots: Robot Anatomy, Configurations, Programming methods and Applications.
GT: Part families, layout, part classification and coding system. Opitz, MICLASS, CODE system

UNIT-V

CAPP: Variant and Generative process planning. **FMS & CIMS:** Building blocks of Flexible Manufacturing systems and their control, Elements of CIMS.
Computer Aided Inspection and QC: Coordinate Measuring Machine, Non-contact inspection: Machine vision, Scanning Laser Beam Devices Quality control. CAD/CAM Integration.
Introduction to Rapid Prototyping Technique and Reverse Engineering.

Suggested Readings:

1. Arvid R. Eide, Roland D. Jenison, Lane H. Mashaw, Larry L. Northup, "Introduction to EngineeringDesign" McGraw -Hill, 1998.
2. Ibrahim Zeid. CAD/CAM, Theory and Practice, McGraw. Hill Inc. New York, 2011.
3. Grover, MP and Zimmers E.W. CAD/CAM, Prentice Hall of India, 1989.
4. Rao, PN. CAD/CAM: Principles and Applications, 2nd Edition, Tata McGraw Hill, New Delhi, 2004.
5. YoramKoren, Computer Control of Manufacturing Systems, McGraw Hill Int, New York, 1994.
6. Ishrat M Mirzana, "CAD/CAM", Radiant Publishing House, 4th Edition, Hyderabad, 2014
7. Elanchezhian. C. Sunder Selwyn. T. Shanmuga Sunder, G, Computer Aided Manufacturing, Laxmi
Publications (P) Ltd., 2nd Edition, New Delhi, 2007.

Course Code	Course Title						Core/Elective
PC591PE	**COMPUTER AIDED PRODUCTION DRAWING LAB**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

The objectives of this course is to impart knowledge of

- To learn design criteria of machine components, importance of production drawing in selection of materials and manufacturing process.
- To learn application of principles to design various machine components by applying limits, tolerances, surface finish and many more techniques of production drawing.

Course Outcomes

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

- Create various models of the machine components.
- Prepare the production drawings of the parts from the given assembly drawing
- Indicate details pertaining to manufacturing requirements and generate the bill of materials.
- Prepare the process sheet for the components drawn.
- Demonstrate the documentation and presentation skills

List of Experiments

1. Part modeling from given assembly drawings (Stuffing Box, Steam Engine Cross Head, Universal Coupling, Foot Step Bearing, Eccentric and Drill Jig) using any solid modeling package.
2. Geometrical dimensioning and tolerance representation on part drawings of above mentioned drawings.
3. Conventional practices indicating Dimensional, Form & Position tolerances.
4. Calculation of limits, suggestion of suitable fits for mating parts with Interference detection.
5. Surface finish, surface treatments- specification and indication methods on the drawings.
6. Generation of production drawings in 2D from part models representing Limits, fits, tolerances, Surface finish, geometrical and form tolerance etc.
7. Preparation of Process sheet incorporating Tool work orientation diagrams.

***Suggested Reading**:*

1. K. L. Narayana, P. Kannaiah and K. Venkat Reddy, "*Production Drawing"*, New Age International (P) Ltd. Revised edition 1997.
2. P. Narasimha Reddy, T. A. Janardhan Reddy and C. Srinivas Rao, "*Production Drawing Practice"*, Hi-Tech Publishers, 2001.

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
PC592PE	**Modern Manufacturing and Testing Lab**						**Core**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**-**	**-**	**-**	**2**	**25**	**50**	**1**

Course Objectives

- To study the features of CNC machine tool.
- To know application of various CNC machine.
- To understand various production processes.
- To understand the working principles of various Modern manufacturing methods.
- To have knowledge of various NDT method***s.***

Course Outcomes

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

1. Decide on the process parameters to be adopted and applicability of various materials that are suitable for mechanical energy based machining processes
2. Decide on the process parameters to be adopted and applicability of various materials that are suitable for electrical and thermal based machining processes
3. Will be able to understand the CNC control in modern manufacturing system.
4. Will be able to distinguish between various manufacturing processes.
5. Will be able to select appropriate manufacturing process to manufacture any component.

List of Experiments:

A: Computer Aided Manufacturing Practice.

1. Step turning and taper turning on CNC.
2. External multiple turning cycles.
3. Grooving and threading operation.
4. Contour milling on CNC.
5. Circular pocketing on CNC

B: Modern Manufacturing Practice.

6. Experiments on Electro Discharge Machine.
7. Develop simple objects using 3D printing technology.
8. Exercise on spinning / flow forming operations.
9. Manufacturing of simple components with composite materials.
10. Study of simple dies and performing blanking and piercing operations by using mechanical presses.

C: Non Destructive Testing.

11. Detection of surface flaws of materials with visible dye.
12. Detection of surface flaws of materials with fluorescent dye.
13. Detection of sub surface flaws using Magnetic Particle Testing using Dry Powder.
14. Detection of sub surface flaws using Magnetic Particle Testing using Wet Powder.

Note: At least ten experiments should be conducted.

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
PC611PE	**ADDITIVE MANUFACTURING TECHNOLOGIES**						**Elective**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	3	-	-	-	30	70	3

Course Objectives:

- To introduce the basics and importance of additive manufacturing/rapid prototyping technologies.
- To familiarize various types of A.M. processes.
- To acquire knowledge, techniques and skills to select relevant additive manufacturing process.
- To learn different rapid tooling techniques.
- To Recognize various STL formats and slicing methods and tessellation
- To explore the potential of additive manufacturing in different industrial sectors.

Course Outcomes:

Students will be able to

- Describe fundamentals of additive manufacturing, classify and explain advantages and disadvantages AM processes.
- Describe the operating principles, capabilities, and limitations of liquid and solid based additive manufacturing systems
- Explain the operating principles, capabilities and limitations of powder based additive manufacturing systems
- Classify rapid tooling techniques and select suitable tooling for a given application.
- Select and use right CAD data formats and AM software in additive manufacturing of a part
- Explore the potential applications of additive manufacturing in different industrial sectors

UNIT-I

Introduction: Prototyping fundamentals: Need for time compression in product development, Need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies.

UNIT-II

Liquid-based AM Systems: Stereolithography Apparatus (SLA): Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages; Solid ground curing (SGC): Process, working principle, Applications, Advantages and Disadvantages; Polyjet: Process, Working Principle, Applications, Advantages and Disadvantages.

Solid-based AM Systems: Laminated Object Manufacturing (LOM): Process, working principle, Applications, Advantages and Disadvantages, Fused Deposition Modelling (FDM): Process, working principle, Applications, Advantages and Disadvantages; Multi-Jet Modelling (MJM): Process, working principle, Applications, Advantages and Disadvantages

UNIT-III

Powder Based AM Systems: Selective laser sintering (SLS): Process, working principle, Applications, Advantages and Disadvantages; Three dimensional Printing (3DP): Process, working principle, Applications, Advantages and Disadvantages; Laser Engineered Net Shaping (LENS): Process, working principle, Applications, Advantages and Disadvantages; Electron Beam Melting (EBM): Process, working principle, Applications, Advantages and Disadvantages.

Rapid Tooling: Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT. Rapid Tooling Classification: Indirect Rapid Tooling Methods: Arc Spray Metal Deposition, Investment Casting, Sand Casting, 3D Keltool process; Direct Rapid Tooling: Direct AIM, LOM Tools, DTM Rapid Tool Process, EOS Direct Tool Process and Direct Metal Tooling using 3DP.

UNIT-IV

AM Data Formats: Reengineering for Digital Representation, STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs, Generic Solution, Other Translators, Newly Proposed Formats, Mesh Refining by Sub Division Techniques.

AM Software: Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3D View, Velocity 2, Rhino, STL View 3 Data Expert and 3D doctor, SurgiGuide, 3-matic, Simplant, MeshLab.

UNIT-V

AM Applications: Application: Material Relationship, Application in Design, Application in Engineering, Analysis and Planning, Aerospace Industry, Automotive Industry, Jewelry Industry, Coin Industry, GIS application, Arts and Architecture; RP Medical and Bioengineering Applications: Planning and simulation of complex surgery, Customised Implants & Prosthesis, Design and Production of Medical Devices, Forensic Science and Anthropology, Visualization of Bio-molecules, Web Based Rapid Prototyping Systems.

Suggested Reading:

1. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific Publications, Third Edition, 2010.
2. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer, 2001
3. Wohlers Report 2000 – Terry Wohlers, Wohlers Associates, 2000
4. Rapid Prototyping & Engineering Applications – Frank W. Liou, CRC Press, Taylor & Francis Group, 2011

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
OE601ME	**Entrepreneurship**						**Open Elective-II**
Prerequisite	Contact Hours per Week				CIE	SEE	Credits
	L	T	D	P			
-	**3**	**-**	**-**	**-**	**30**	**70**	**3**

Course Objectives

- To motivate students to take up entrepreneurship in future
- To learn nuances of starting an enterprise & project management
- To understand the design principles of solar energy systems, their utilization and performance evaluation
- To understand the behavioural aspects of entrepreneurs and time management

Course Outcomes

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

1. Understand Indian Industrial Environment, Entrepreneurship and Economic growth, Small and Large Scale Industries, Types and forms of enterprises.
2. Identify the characteristics of entrepreneurs, Emergence of first generation entrepreneurs, Conception and evaluation of ideas and their sources.
3. Practice the principles of project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis.
4. Apply the concepts of Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques
5. Understand the Behavioural aspects of entrepreneurs, Time Management, Various approaches of time management, their strengths and weakness. The urgency addiction and time management matrix.

UNIT-I

Indian Industrial Environment-competence, Opportunities and Challenges. Entrepreneurship and Economic growth. Small Scale Industry in India, Objectives, Linkage among small, medium and heavy industries. Types of enterprises.

UNIT-II

Identification and characteristics of entrepreneurs. Emergence of First generation entrepreneurs, environmental influence and women entrepreneurs. Conception and evaluation of ideas and their sources. Choice of Technology - Collaborative interaction for Technology development.

UNIT-III

Project formulation, Analysis of market demand, Financial and profitability analysis and Technical analysis, project financing in India.

UNIT-IV

Project Management during construction phase, project organization, project planning and control using CPM, PERT techniques. Human aspects of project management. Assessment of tax burden.

UNIT-V

Behavioural aspects of entrepreneurs: Personality - determinants, attributes and models. Leadership concepts and models. Values and attitudes. Motivation aspects. Change behaviour. Time

Management: Various approaches of time management, their strengths and weaknesses. The urgency addiction and time management matrix.

Suggested Readings:

1. Vasant Desai, *"Dynamics of Entrepreneurial Development and Management",* Himalaya Publishing House, 1997
2. Prasanna Chandra, *"Project-Planning, Analysis, Selection, Implementation and Review",* Tata McGraw-Hill Publishing Company Ltd. 1995.
3. Stephen R. Covey and A. Roger Merrill, *"First Things First",* Simon and Schuster Publication, 1994.
4. G.S. Sudha, *"Organizational Behaviour",* 1996.
5. Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005.

Course Code	Course Title						Core / Elective
OE602ME	**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:

6. Select and apply the knowledge of measuring tools for external, internal and angular measurements for promoting the qualitative production management.
7. Adapt the principles of optical measurements in measurement of screw and gear profiles.
8. Choose and practice the appropriate methods of force measuring devices principles for required situation.
9. Demonstrate the need of machine alignment test for qualitative production.
10. Practice calibration principles for maintaining the required precision of instruments / tools.
11. Select and practice the methods of temperature measurement.
12. 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.
13. 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