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

S.No.	Course Code	Course Title	Scheme of Instructions				Scheme of Examination			Credits
			L	T	P/D	Contact Hours/ Week	CIE	SEE	Duration in 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-I	Professional Elective – I	3	-	-	3	30	70	3	3
5	PEME - II	Professional Elective – II	3	-	-	3	30	70	3	3
6	OEC - 1	Open Elective – 1	3	-	-	3	30	70	3	3
Laboratory Course										
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	
PE611PE	Additive Manufacturing Technology
PE612ME	Automobile Engineering

Professional Elective-II		
S. No.	**Course Code**	**Course Title**
1	PE621PE	Entrepreneurship Development
2	PE622PE	Plastic Engineering & Technology
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
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
PE621PE	ENTREPRENEURSHIP DEVELOPMENT						
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
-	3	--	--	--	30	70	3

Course Objectives:

1.	To understand the entrepreneurship and economic growth.
2.	To grasp the knowledge of Collaborative interaction of entrepreneurs.
3.	To learn the knowledge of Project formulation &Project Management

Course Outcomes:

1.	To differentiate between Small medium and heavy Scale industries.
2.	To recognize the Emergence women entrepreneurs for Technology development.
3.	To understand the project formulation and project management.
4.	To understand the behavioural aspects of entrepreneurs.

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 Reading:

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 Behaviuor",* 1996
5. 6.	Robert D. Hisrich, Michael P. Peters, *"Entrepreneurship",* Tata Me Graw Hill Publishing Company Ltd., 5lh Ed., 2005

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Course Code	Course Title						Core/Elective
PE622PE	PLASTIC ENGINEERING AND TECHNOLOGY						
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
-	3		--	--	30	70	3

Course Objectives:

1. To learn the basics of plastics and processing methods used in plastic manufacturing
2. To gain knowledge about injection moulding, polymers and thermoplastics.

Course Outcomes:

At the end of the course, the students will be able to
1. Analyse the plastic material properties.
2. Industrial applications and manufacturing methods.

Unit-I
General properties of plastics: Polymeric Materials, Plastics available to the designer, Engineering Plastics, Thermosets, composites, structural foam, Polymer alloy, selection of plastics, Mechanical properties, Impact Enhancement, Degradation, wear resistance and frictional properties,special properties processing, costs -selection for strength at minimum cost.
Unit-II:
Mechanical properties of plastics -Deformation, Viscoelastic behaviour of plastics, short term testing of plastics, long term testing of plastics, Design methods of plastic using deformation data, Mathematical models of viscoelastic behaviour, Intermittent loading, Deformation behaviour of reinforced plastics.
Unit-III
Mechanical properties of plastics -Fracture. The concept of stress concentration, Energy approach to fracture, Stress Intensity Factor approach to fracture, J-integral approach, General fracture behaviour of plastics, creep failure of plastics. Fatigue of plastics, Impact behaviour of plastics
Unit-IV
Processing of plastics. Extrusion -Mechanism of flow, analysis of flow in extruder, Extruder volumetric efficiency, power requirements. Injection Moulding: Moulds, CAD of moulds, structural foam Injection moulding, Reaction injection moulding, Injection blow moulding, injection moulding of thermosets. Thermoforming, calendering, Rotation moulding, compression moulding, transfer moulding, automatic processes, die design of plastics, Joining process -Hot air, ultrasonic, and solvent welding.
Unit-V
Analysis of polymer melt flow. General behaviour of polymers melts, Isothermal flow of polymers Melts, Residence and Relaxation times, Experimental Methods used to obtain flow data

Suggested Reading:

1. Plastics and Rubber, *Engineering Design and Application,* R.J. Crawford.
2. N.A. Waterman, *The selection and use of Engineering Materials*
3. Rossi, *WeldingEngineering*, McGrawHill

Course Code	Course Title						Core/Elective
PE623ME	DESIGN FOR MANUFACTURE						
Prerequisite	Contact Hours per week				CIE	SEE	Credits
	L	T	D	P			
-	3	--	--	--	30	70	3

Course 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

Course 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, fine blanking, four slide parts, spring and wire forms, spun metal parts, cold headed parts, extruded parts, tube and section bends, rolled formed parts, power metal parts, forging electro forming parts, specialized forming methods, turned parts, machined round holes, drilled parts, milled parts
Unit-III
Metallic Components Design: Planned shaped and slotted parts, screw threaded contoured and internal ground parts, center less ground, electrical discharged, rolled furnished parts, electro chemical and advanced machine parts, Sand cast, diecast, investment cast and other cast products.
Unit-IV
Non Metallic Component Design: Thermosetting plastic, injection moduled and rotational moulded parts, blow moulded, welded plastic articles, ceramics. Assembled Parts Design: Welded parts, arc, resistance, brazed and soldered parts, gear box assembly, bearing assembly
Unit-V
Assembled Parts Design: Retension, bolted connection, screwed connections, flanged connections, centered connections, press fitted connections, surface finishing, plated parts, heat treated parts, NC machining, group technology, low cost automation, computer aided manufacture, product design requirements. Case Studies: Identifications of economical design and redesign for manufacture

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:

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