## List of Electives

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Total Credits: 182
COURSE OBJECTIVES:

- To impart the knowledge of working principle of advanced machining processes
- To teach the influence of parameters on the performance of advanced machining processes
- To educate the merits, demerits and applications of advanced machining processes

Metal Cutting Technology: Introduction to metal cutting - tool nomenclature and cutting forces - thermal aspects of machining - tool materials - tool life and tool wear - traditional and nontraditional machining.


Chemical and Electrochemical Processes: Chemical Milling - Photochemical Milling - Electropolishing - Electrochemical Machining - Electrochemical Drilling - Shaped Tube Electrolytic Machining – working principle, merits, demerits and applications.

Thermal Processes: Electric Discharge Machining - Laser Beam Machining - Electron Beam Machining - Plasma Beam Machining - Ion Beam Machining – working principle, merits, demerits and applications.

Hybrid Processes: Electrochemical Grinding, Honing, Superfinishing and Buffing - Ultrasonic Assisted ECM - Electroerosion Dissolution Machining - Abrasive Electrodischarge Machining - EDM with Ultrasonic Assistance - Laser Assisted Machining – working principle, merits, demerits and applications.

REFERENCES:

7. McGeough, J "Advanced Methods of Machining", London. New York: Chapman and Hall,

**COURSE OUTCOMES:**

1. Describe the working principle of advanced machining processes.
2. Explain the effect of various process parameters on the performance of advanced machining processes.
3. Summarise the merits, demerits and applications of advanced machining processes.
4. Identify the suitable advanced machining processes based on the applications.

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COURSE OBJECTIVES:

- To acquire deep knowledge on metal forming techniques.
- To analyze the theory of plasticity and its applications.
- To gain knowledge about the advancement in forming technologies.

Mohr’s Circle, Plastic instability, Tensile test, Advantages of true stress and true strain diagrams etc., Various Yield theories and comparison - Von-Mises Yield theory, Tresca Yield theory, Solving problems related to Yield theories.

Plastic instability in biaxial tension, Plastic instability using old Hill’s Yield theory, Plastic instability using latest Hill’s Yield theory, Plastic instability using Bassani’s yield theory Constitutive responses, physics of plasticity with application of plasticity theory for different materials, rate independent plasticity, Anisotropy in sheet metals, Hill’s Anisotropic Plasticity theory, Special cases, Generalization of Hill’s criterion, Bassani’s Yield theory, M-K analysis for imperfect sheets, Upper bound theorem, Plane strain, Simple indendation, Compression between smooth plates, Upper bound problems, Plastic buckling, dynamic plasticity, 1-D wave, special topics from current research.

Slab analysis, Sheet drawing, Wire/rod drawing, Direct compression in plane strain, Sticking friction at interface, Axisymmetric compression, extrusion, Cold rolling theory of strip or plate Slip line filed theory, Governing stress equations, Properties of SLF, Velocity equations, Derivation of Velocity diagram, Simple stress boundary conditions, Thick walled cylinder under internal pressure solution by SLF method, Processes, Theory of plasticity for porous materials.

REFERENCES:

5. Plasticity: Fundamentals and applications, P. M. Dixit and U. S. Dixit
6. Theory of Plasticity, J. Chakrabarty
COURSE OUTCOMES:

1. Recognize the various metal forming techniques and formability
2. Apply the theory of plasticity for various metal forming Processes and designing metal forming processes.
3. Describe and Using the advanced forming technologies.

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COURSE OBJECTIVES:

- To develop the skills needed to weld.
- To make the students learn basics of welding ferrous and non-ferrous metals.
- To make the students learn basic set-up configurations of various welding equipment and their applications.

Welding processes classification, arc welding processes- solid state welding processes, plasma arc welding and ultrasonic welding - Resistance welding process- different types weld joints, welding positions. Brazing, soldering and adhesive bonding, process principles & applications.


Friction Surfacing, Friction stir spot welding, Explosive Welding, Welding of Al and Mg based alloys - Dissimilar welding of Non-ferrous alloys - Friction welding with Cu interlayer.


Heat transfer and solidification - Analysis of stresses in welded structures – Pre and post welding heat treatments – Weld joint design – welding defects-Inspection & testing of weld joints - Safety aspects in welding.

REFERENCES:

1. Dr.R.S.Parmer "Welding processes and Technology" Khanna Publishers.
COURSE OUTCOMES:

1. Understand principles, operations and applications of different casting and welding processes.
2. Analyse the effects of process parameters on the quality of cast and weld products.
3. Select the NDT techniques for the evaluation of cast and weld components.

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PR604 Advanced Tooling and Automated Inspection

COURSE OBJECTIVES:

- To train students in state of art of Tooling in Manufacturing
- Design and Develop flexible tooling for Manufacturing
- Design and Develop automated inspection systems

Introduction to Principles of Tooling in Manufacturing-Economics of Tooling- Pre-Design Product and Process Analysis –Soft and Hard Automation- Tooling for Machining-Tool Changers-Tool Presets-Flexible Tooling

Tooling for Forming- Evolution of Dies, Forging, Bending and Drawing and Extrusion Processes- Tooling for Casting processes –Mechanization -Tooling in Non Traditional Manufacturing –Tooling for Micro Manufacturing-Tooling for Physical and Mechanical joining Processes-

Tooling for CMM Principles of Gauging - New concepts for gaging, inspection, checking, machine vision, and robotic testing. Smart Inspection Systems - Techniques and Applications of Intelligent Vision -Stages of automated visual inspection (AVI) and "smart" inspection systems- AVI process, from illumination, image enhancement, segmentation and feature extraction, through to classification.

Tooling Practice in Traditional and Non-traditional Machining- Machining Centres, Turning centers, Micromachining, Mechatronics AS/RS, Robots and CMM

REFERENCES:


COURSE OUTCOMES:

1. State of Art in Tooling in Manufacturing and Inspection
2. Design and Develop tooling for modern manufacturing
3. Design and Develop Automated Inspection Systems

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COURSE OBJECTIVES:

- To develop advanced machine language for operating machine tools.
- To apply computer numerical control techniques for making macro and micro products.
- To understand cellular manufacturing techniques.

Numerical Control (NC) - input media - design considerations of NC machine tools - functions of MCU- controls and system devices - CNC.

CNC programming - manual part programming – preparatory, miscellaneous functions – computed aided part programming - post processors - APT programming- programming for CNC turning center, machining center and CNC EDM.


Part families-classification and coding-cellular manufacturing- production flow analysis- automated material handling systems- automated storage systems-automatic data capture- automated assembly systems-industrial robots – configurations- applications.

REFERENCES:


COURSE OUTCOMES:

1. Develop advanced machine language for operating machine tools.
2. Apply computer numerical control techniques for making macro and micro products.
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COURSE OBJECTIVES:

1. To enable the students to understand the role of manufacturing management in organizational decision making.
2. To study the strategic, tactical and operational decision making tools in order to model a manufacturing or a service system.
3. To understand the application of manufacturing management policies and techniques to the manufacturing and service organizations.

Strategic, Tactical and Operational decisions – Supply chain management-key issues-
General discrete location-allocation problems - features and formulations. Facility location models - Median model - Distribution model - Brown and Gibson model, Min-max algorithm, Gravity location algorithm-solving using GAMS software.

Aggregate production planning –heuristics-pure mixed strategies, transportation and linear models – Inventory management –Inventory control policies- EOQ models-models with price breaks

Material Requirement Planning (MRP) - working of MRP - master production scheduling - Lot sizing in MRP system-rough cut capacity planning -capacity requirement planning, ERP and softwares.

Operations scheduling - Flow shop - Johnson's rule, CDS heuristics, Palmer heuristics-
Assembly Line Balancing- Project Scheduling-Quality Management-Taguchi Method

Introduction to Industry 4.0, Role of artificial intelligence and analytics in manufacturing, Industrial IOT

REFERENCES:

3. O. Perez, S. Saucedo, J. Cruz, Manufacturing 4.0: The Use of Emergent Technologies in Manufacturing, 2018
### COURSE OUTCOMES:

1. Understand the role of manufacturing management in organizational decision making.
2. Build and analyze quantitative models for organizational decision making.
3. Select appropriate tools for decision making.
4. Apply tools for modelling of complex systems.
5. Analyze the outcome and offer suggestions for improvement.

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COURSE OBJECTIVES:

- To impart the practical knowledge of working principle of advanced machining processes.
- To teach the influence of parameters on the performance of advanced machining processes by practice, simulation and analysis.
- To impart the practical knowledge of metal forming techniques.
- To teach the theory of plasticity by practice, simulation and analysis.

Among the following list of experiments at least 12 experiments need to be carried out within the course duration.

List of Experiments

1. Analysis of cutting forces during turning/drilling process.
2. Analysis of temperature during turning/drilling process.
3. Pin-on-disc based tribological characterization of ferrous/ non-ferrous materials at different environment.
5. Study on the effect of process parameters in Electro-Chemical/Electric-Discharge Machining
7. Laser surface melting of ferrous / non-ferrous materials.
8. Laser surface alloying.
9. Laser marking / engraving on metals.
10. Laser micro-welding, micro drilling / micro channeling.
11. Analysis of orthogonal cutting operation by using Software.
12. Analysis of drilling operation by using Software.
13. Analysis of water jet cutting on an aluminum plate by using Software.
15. Heat generation due to contact friction by using Software.
17. Construction WLD and analysis of Wrinkling Limit.
18. Analysis of strain hardening during sheet metal forming.
19. Analysis of anisotropy in sheet metals.
20. Analysis on extrusion of metals.
22. Advanced sheet metal operation by using Software.
23. Create intermediate stage of forming on a hybrid sheet metal part by using Software.
24. Creating a sheet metal component and analyzing the formability by using Software.
25. Analysis of cold rolling of a bar by using Software.
COURSE OUTCOMES:
1. Describe the working principle of advanced machining processes.
2. Analyse the effect of various process parameters on the performance of advanced machining processes.
3. Recognize the various metal forming techniques and formability.
4. Apply the theory of plasticity for various metal forming Processes and designing metal forming processes.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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PR608 Advanced Casting and Welding Lab.

COURSE OBJECTIVES:

- To enable the students to understand the Design, simulate and investigation of casting processes to produce components using software’s.
- To make the students to gain practical knowledge about advanced casting technology.
- To enable the students to understand the Design, simulation and investigation of welding processes to fabricate components using software’s.
- To make the students to gain practical knowledge about advanced welding technology.

Among the following list of experiments student can do 10 experiments for their lab class

List of Experiments:

1. Design, Simulate and investigation of gating system for a given component (ferrous / non ferrous) using CAD software.
2. Design, Simulate and investigation of risering system for a given component (ferrous / non ferrous) using CAD software.
3. Design, Simulate and investigation of Runner design a given component (ferrous / non ferrous) using CAD software.
4. Design, Simulate and investigation of pattern layout for a given component using CAD software.
5. Die design, Simulation and investigation for pressure die casting / centrifugal casting using CAD software.
6. Fluidity analysis of behavior of molten material to make spiral components during casting using CAD software.
7. Simulate and Analyses of plastic parts mould design for their manufacturability and tooling development using CAD software.
10. Study on casting of materials using microwave energy.
11. Identification and analysis of casting product defects using CAD software.
12. Investigation on arc welding process using SIMUFACT/ COMSOL.
13. Investigation on resistance spot welding process using SIMUFACT.
14. Investigation on laser beam welding process using SIMUFACT.
15. Investigation on Residual Stresses in a Butt-welded Joint using COMSOL.
16. Investigation on Friction stir welding using ABAQUS.
17. Study on bead geometry in fusion welding of ferrous alloys using COMSOL multiphysics software.
18. Study on weld bead geometry of Resistant Welding process on Advanced materials and materials and investigate about the process parameters using FEA software.
19. Study on casting of materials using microwave energy.
20. Study on Application of Ultrasonic welding process on Advanced materials and investigate about the process parameters.
21. Study on Application of Microwave Welding on Advanced materials and materials and investigate about the process parameters.
22. Study on Application of Fusion Bonding Process on Advanced materials and materials and investigate about the process parameters.
23. Study on Application of Frictional Vibration Welding process on Advanced materials and materials and investigate about the process parameters.
24. Study on Application of Resistant Welding process on Advanced materials and materials and investigate about the process parameters.
25. Study on Application of Friction stir welding process on Advanced materials and materials and investigate about the process parameters. Measurement of Bead geometry on Arc welded Ferrous Alloy
27. Investigation on Microstructure Analysis of Arc welded non Ferrous Alloys.
29. Investigation on temperature distribution analysis during arc welding of aluminum alloys.
30. Investigation on effect of post weld heat treatment on the micro hardness of arc welded ferrous Alloys

COURSE OUTCOMES:

1. Student able to identify and select suitable casting process to make components in industry.
2. Student able to identify and select suitable welding process to make components in industry.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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COURSE OBJECTIVES:

- To Learn the automation system using fluid power control system and its applications.
- To Learn the manufacturing process simulation and generation G-codes/ M-Codes for the given part drawing.
- To Learn the CNC Programming and write G-Codes/M-Codes for the given part drawing
- To Learn the Robot programming and function of ASRS

1. Exercise on hydraulic system: Design, construct and simulation of different hydraulic circuits for the given applications.
2. Exercise on Pneumatic system: Design, construct and simulation of different Pneumatic circuits for the given applications.
3. Simulation of Electro-pneumatic latch circuits / Logic pneumatic circuits / electro pneumatic sequencing circuits
5. Exercise on Electro-Pneumatic system: Design, construct and simulation of different Electro-Pneumatic circuits for the given applications.
6. Exercise on design of fluid power control circuit for real time industrial application.
7. Exercise on Manufacturing simulation and generation G-codes/M-Codes for the given Turning profile using Pro-E /Creo.
8. Exercise on Manufacturing simulation and generation G-codes/M-Codes for the given Milling profile using Pro-E /Creo.
9. Exercise on Plain turning, Step turning and facing operations on EMCO turning machine.
10. Exercise on Plain turning, Step turning, facing operations and External threading operation on STC 15 machines.
11. Exercise on Profile milling operation on VMC machine.
12. Exercise on Circular pocketing / Rectangular pocketing / drilling/ Mirroring operations on EMCO milling machine.
13. Exercise on Measurement of form tolerance (circularity, cylindricity and perpendicularity) using CMM.

REFERENCES:


COURSE OUTCOMES:

1. Apply fluid power control system for industrial automation.
2. Generate G-codes/M-Codes for the given part drawing using CAD software by simulating manufacturing process.
3. Understand and write CNC Programme: G-codes/M-Codes for the given part drawing.
4. Write the Robot programming and understand function of ASRS.
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PR610 Process Modelling and Additive Manufacturing Lab.  

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COURSE OBJECTIVES:

- To perform modelling and simulation of manufacturing processes
- To execute product development phases
- To develop eco-friendly products

1. Analysis of stress strain distribution in a structural loading of composite bar using MATLAB codes.
2. Transient heat transfer analysis of a rectangular slab using a FEA package.
7. Product development activity – Concept design and Detailed design.

COURSE OUTCOMES:

1. Perform modelling and simulation of manufacturing processes
2. Competence to execute product development phases
3. Develop environmentally friendlier products

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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ELECTIVES

MATERIALS & PROCESS STREAM

PR611 Modeling of Manufacturing Processes

COURSE OUTCOMES:

- To arrange the application of numerical method for non-linear problems
- To apply numerical methods for manufacturing processes
- To evaluate the numerical results of manufacturing processes

Review of manufacturing processes, need for numerical solution – Review of basic concepts of numerical methods

FE concepts – variational and weighted residual approaches – Element types – 2D elements – plane triangular, quadrilateral, 3 dimensional axi-symmetric, plate and shell elements – mapping of elements

FE solution for Steady state and transient problems. FE procedure for non-linear problems - Material and geometric non-linearities – solution using implicit and explicit methods

Lagrangian and Eulerian formulations for modelling of machining, rolling, forging, drawing. ALE elements

Thermal modeling for induction hardening, arc welding, cooling of castings – deduction of cooling rate and metallurgical transformations.

REFERENCES:

1. Arrange the application of numerical method for non-linear problems.
3. Evaluate the numerical results of manufacturing processes.

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COURSE OBJECTIVES:

- To learn the overall view of Polymeric Matrix Composite materials.
- To acquire the knowledge of different fabrication methods of Polymeric Matrix Composites material and its Characterization.
- To learn the Weldability and Machinability characteristics of Polymeric Matrix Composite materials.
- To select the suitable Polymeric Matrix Composite materials for industrial applications considering the Environmental issues.


Primary Manufacturing Techniques of PMC material: Lay-up process, Vacuum-Bagging Process, Autoclave Molding, Compression Moulding process, Injection moulding process, transfer moulding process, filament Winding process and Pultrusion process.

Secondary Manufacturing Techniques of PMC material: Forming methods for Polymers and polymeric composite material- component design consideration. Machinability study (turning, milling and drilling) on polymeric composite material.


REFERENCES:

5. “Process Selection from design to manufacture” published in 1997 by Edward Arnold.

COURSE OUTCOMES:

1. Acquire the knowledge of the polymers matrix and reinforcement materials used in polymer matrix composites.
2. Describe manufacturing methods and characterization of polymer matrix composites.
3. Perform Forming, Joining & machining operation to make product from the polymer matrix composites.
4. Select and Apply the appropriate polymer matrix composites material for recent industrial applications & confront environmental issues.

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COURSE OBJECTIVES:

- To identify the effect of heat treatment in alloying elements
- To apply surface modification techniques
- To find the defects occurring in heat treated parts


TTT & CCT diagram for steels-Various heating media used for heat treatment, furnaces, Temperature and atmosphere control- Selection of furnace for heat treatment.


REFERENCES:

COURSE OUTCOMES:

1. Identify the effect of heat treatment in alloying elements
2. Apply surface modification techniques
3. Find the defects occurring in heat treated parts

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COURSE OBJECTIVES:

- To apply the knowledge of welding in Heavy Engineering
- To apply the knowledge of welding in Automotive Industries
- To apply the knowledge of welding in Nuclear Power


Application of welding in oil & gas industries: orbital pipe welding, welding consumables, fabrication codes, inspection & testing, acceptance criteria.

Application of welding in Nuclear Power: Materials, processes, fabrication codes, inspection & testing, reasons for stringent quality control measures.

Application of welding in automotive industries: Thin sheet welding, selection of materials and welding processes, inspection and testing procedure, acceptance criteria.

Application of welding in shipbuilding & Aerospace Industry: Materials involved, welding processes, fabrication code, inspection & testing, acceptance criteria.

REFERENCES:


COURSE OUTCOMES:

1. Apply the knowledge of welding in Heavy Engineering.
2. Apply the knowledge of welding in Automotive Industries.
3. Apply the knowledge of welding in Nuclear Power.
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COURSE OBJECTIVES:

1. To understand the fundamental properties of laser beams as advanced materials processing and manufacturing tool.
2. To describe the various types of operation in laser surface treatment, welding, cutting and drilling of different materials.
3. To develop skills necessary to effectivelyanalyse laser based physical processes and their implications in material processing and manufacturing processes.


Laser welding-process arrangement - mechanisms - applications –modes of welding-conduction limited welding-key hole welding-hea t flow theory - one dimensional heat flow model for stationary and moving point source - simulation of laser welding.


REFERENCES:

COURSE OUTCOMES:

1. Compare the types of lasers and its applications.
2. Employ laser for surface engineering, welding, cutting and drilling.
3. Analyse the micro machining processes by Laser

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COURSE OBJECTIVES:

- Identify various parts of machine tools
- Apply various design aspects of spindles and bearings
- Reduce vibration and chatter developing on machine tools

Metal cutting machine tools and their specifications - machine beds and columns - relative merits of different types of beds and columns - design of beds and columns - force on cutting tool.

Types of slideways and design of slideways - wear adjustments in slideways, surface treatment for slideways.

Design of spindles – example for lathe, drilling machine and milling machine, Design of bearing- example for lathe, drilling machine and milling machine, choice of bearings.


REFERENCES:


COURSE OUTCOMES:

1. Identify various parts of machine tools.
2. Apply various design aspects of spindles and bearings.
3. Reduce vibration and chatter developing on machine tools.
### MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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COURSE OBJECTIVES:

1. To describe the types of polymers, rubbers and its manufacturing techniques
2. To describe the application, types of glass and ceramics and their manufacturing methods
3. To understand the knowledge in types of composites and their manufacturing techniques


Glass - characteristics - application - glass making - Glass forming machines - hollow wares flat glasses, fiberglass, bulbs, bottles, heat absorbing glasses, amber glass and their manufacturing methods, general plant layouts for manufacture of different types of glasses.


REFERENCES:


COURSE OUTCOMES:

1. Describe the types of polymers, rubbers and its manufacturing techniques
2. Describe the application, types of glass and ceramics and their manufacturing methods
3. Knowledge in types of composites and their manufacturing techniques

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</table>
COURSE OBJECTIVES:

- To classify the mechanical properties of materials.
- To relate the various forming process.
- To apply the knowledge in formability.

Crystal structure, Slip planes, Slip systems and Formability, Close packed planes and directions, Tensile test, Yielding behavior, True stress, strain, Strain hardening, Dislocations, Tensile instability, Constitutive material relationships, Strain rate and sensitivity, Volume constancy principle, Mass constancy principle

Effect of Mohr's circle on Formability, Formability of low carbon steels, Automobile grade steels

Effect of grain size on Formability, Effect of second phase particles on formability

Formability of Carbon - Manganese steels, Micro alloy steels, HSLA steels, I.F steels, Dual phase steels, etc., Formability of Stainless steels

Diffused necking and localized necking in tensile test, Super plasticity and its applications, Deep drawing and deep drawability of sheet metals, Defects in deep drawing

Cold working, Hot working and Warm working, Recrystallization, Forming Limit Diagram, Workability of materials.

REFERENCES:


COURSE OUTCOMES:

1. Classify the mechanical properties of materials.
2. Relate the various forming process.
3. Apply the knowledge in formability.
MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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COURSE OBJECTIVES:

- To understand structure and deformation mechanics of materials.
- To understand strengthening mechanisms.
- To identify different modes of failure of materials.
- To apply basic deformation mechanics to multi-materials.
- To evaluate mechanical properties of different materials.

Introduction: Overview on elastic and plastic behavior, and structure of materials; Isotropic and anisotropic properties of cubic and noncubic crystals.

Crystal plasticity: dislocation geometry and energy, dislocation mechanics, crystal defects, slip system, hardening, yield surface, micro-to-macro plasticity; Strain-rate and temperature dependence of flow stress; Mechanical Twining, Martensitic transformation, Shape memory and superelasticity; Strengthening mechanism of metals.

Material testing: tensile test, hardness test, fatigue, creep and impact testing; Heat treatment; Concept of fatigue, fracture, creeps and stress rupture; Embrittlement and residual stress.

Mechanical behavior of Ceramics, glasses, polymeric materials, Deformation behavior of metal sandwich materials and metal-matrix composite material, Rheological behavior, and Viscoelasticity.

REFERENCES:

COURSE OUTCOMES:

1. Understand structure and deformation mechanics of materials.
2. Understand strengthening mechanisms.
3. Identify different modes of failure of materials.
4. Apply basic deformation mechanics to multi-materials.
5. Evaluate mechanical properties of different materials.

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COURSE OBJECTIVES:

- To classify the composite materials.
- To categorize the properties of composite materials.
- To apply the knowledge of matrix in composite materials.

Classification, Types, characteristics and selection of composites, prepegs, sandwich construction.


Macro Mechanical analysis of laminate - Kirchoff hypothesis – CLT, A,B,& D matrices - Engineering constants - Special cases of laminates, Failure criterion.

Manufacturing processes and Quality assurance of composites.

Metal matrix composites, Application developments - future potential of composites.

REFERENCES:


COURSE OUTCOMES:

1. Classify the composite materials.
2. Categorize the properties of composite materials.
3. Apply the knowledge of matrix in composite materials.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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COURSE OBJECTIVES:

1. To impart knowledge on various inspection techniques available to check weld quality.
2. To develop the knowledge on the selection of appropriate Non-destructive techniques.

Visual Inspection: Fundamentals of Visual Inspection - metallic materials, raw materials andwelds - Inspection objectives, inspection checkpoints, sampling plan, inspection pattern etc. classification of indications for acceptance criteria - Codes, Standards and Specifications (ASME, ASTM, AWS etc.) - Capabilities, Limitation and Applications

Liquid Penetrant Testing: Principles - types and properties of liquid penetrants - developers - advantages and limitations of various methods - Control and measurement of penetrant process variables - Limitation and Applications

Magnetic Particle Testing: Theory of magnetism - ferromagnetic, Paramagnetic materials - advantages - Circular magnetisation techniques, Limitation and Applications

Ultrasonic Inspection Methods, Equipment/Materials: Principle of pulse echo method, through transmission method, resonance method - Advantages, limitations - Focussing Techniques (SAFT), Time of Flight Diffraction (TOFD), Signal Analysis. Capabilities, Limitation and Applications

Characterization: X-ray Diffraction (XRD) - SEM, Photoluminescence (PL) – Raman Spectroscopy, UV-Vis-IR Spectrophotometer –AFM.

REFERENCES:


COURSE OUTCOMES:

1. Select appropriate non-destructive techniques.
2. Apply surface modification techniques.
3. Compare the merits of various non-destructive techniques.
MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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PR622 Fabrication of Smart Materials and MEMS

COURSE OBJECTIVES:

1. To describe the overview of different kinds of smart materials and their applications
2. To describe the various fabrication processes of smart materials and MEMS
3. To deliberate the fundamentals of mechanics for design of smart materials


Smart composites - piezoelectric materials, shape memory alloys, magnetic materials - Electro and magneto-statics, Electro active polymers and electrostrictive materials - measurement techniques for MEMS.

Fabrication processes - Structure of silicon and other materials Silicon wafer processing; Thin film deposition, Lithography, Etching, LIGA, Micromachining, Thick-film processing.


Electronics and packing - Semiconductor devices - Signal conditioning for microsystems devices-Vibration control of a beam - Integration of microsystems and microelectronics - Packaging of microsystems.

REFERENCES:

1. Engineering analysis of smart material systems, Donald J. Leo, John Wiley Sons.
2. Smart material systems: model development, R.C. Smith, SIAM.
COURSE OUTCOMES:

1. Describe the overview of different kinds of smart materials and their applications.
2. Describe the various fabrication processes of smart materials and MEMS.
3. Deliberate the fundamentals of mechanics for design of smart materials.

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COURSE OBJECTIVES:

1. To compare the use of different surface engineering techniques.
2. To select appropriate thermal process to alter the material surface.
3. To apply laser for surface modification.

Introduction- Significance of surface engineering- Solid surface- Surface energy-
Superficial layer- Physico-chemical parameters- Properties of the superficial layer-
Surface coating- Classification.

Physical vapor deposition (PVD): Ion plating- Sputter deposition- Reactive deposition-
Magnetron sputtering- Chemical vapor deposition (CVD)- Ion implantation- Electron
beam technology- Applications.

Thermal Spraying Techniques- Flame Spraying, Atmospheric Plasma Spraying (APS),
Vacuum Plasma Spraying (VPS), Detonation-Gun Spraying (D-GUN), High-Velocity Oxy-
Fuel (HVOF) Spraying-Applications.

Laser surface engineering- Laser transformation hardening - Laser remelting- Laser
alloying- Laser cladding- Laser ablation- Pulsed laser deposition- Laser doping - Laser
crystallization- Laser surface texturing- Laser shock peening.

Methods of characterization-Microstructure- Mechanical: Adhesion-Hardness-micro
hardness- Residual stress-Friction-Wear- Physical: Porosity-Density- Electrical:
Conductivity- Magnetic- Chemical.

REFERENCES:

1. Tadeusz Burakowski, Tadeusz Wierzchon, “Surface Engineering of Metals-
Springer Verlag, 2010.
COURSE OUTCOMES:

1. Compare the use of different surface engineering techniques.
2. Select appropriate thermal process to alter the material surface.
3. Apply laser for surface modification.

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COURSE OBJECTIVES:

- To understand the importance of friction, wear and lubrication of contacting surfaces.
- To understand the mechanism of different forms of wear.
- To describe the various forms of lubrication.
- To measure the Micro/ Nano technology using industrial applications.


REFERENCES:

COURSE OUTCOMES:

1. Apply the knowledge of tribology in industries.
2. Identify the friction and its effect.
3. Analyse wear of different forms.

Mapping of programme outcomes with course outcomes:

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COURSE OBJECTIVES:

- To provide a comprehensive idea regarding the friction materials and its performance.
- To explore various ingredients and fabricate different types of friction composites.
- To demonstrate knowledge of various industrial standards for testing the friction composites.
- To identify the difference between OE and after-market friction materials.


Quality Assurance Characterizations: Introduction- Types- Physical, Chemical, Mechanical, Thermal Characterization- Indian and Global standards involved in the testing of friction materials- Case studies and calculations

Tribological Characterizations: Introduction- Overview of testing- Screening tests- Simulated conditions tests- Field testing- Documentation and interpretation of results- Case studies on the problems faced during real-time testing

Inspection and Field Case Studies: Introduction- Surface Characterization- SEM- Elemental Mapping- XRD analysis- Surface Roughness (AFM/3D interferometer)- Case studies on problems affecting the performance

REFERENCES:

3. HO Jang, Chapter Title: Brake Friction Materials, Book Title: Encyclopedia of Tribology, pp 263-273, 2013, Springer US.

4. Jayashree Bijwee, Chapter 17: Multifunctionality of non-asbestos organic brake materials, Book Title: Multifunctionality of Polymer Composites: Challenges and New Solutions, pp 551-570, 2015, Elsevier, USA.


**COURSE OUTCOMES:**

1. Provide a comprehensive idea regarding the friction materials and its performance.
2. Explore various ingredients and fabricate different types of friction composites.
3. Demonstrate knowledge of various industrial standards for testing the friction composites.
4. Identify the difference between OE and after-market friction materials.

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COURSE OBJECTIVES:
- To understand the fundamentals of advanced casting processes.
- To enable the students to understand the gating system design, die/pattern design and mechanization of foundry.
- To enable the students to understand the Solidification of ferrous and non-ferrous alloys.
- To enable the students to understand the Modern molding and core making processes and equipment’s.
- To enable the students to understand the Special Casting processes.


Design considerations in manufacturing of patterns and dies: Computer Aided pattern design and manufacture, pattern making machines and equipments, Computer aided design of dies in die casting and centrifugal casting, materials used and allowances in patterns and dies. Design of gating system: Elements and types of gating systems, gating ratio pressurised & unpressurised gating, systems- applications, Risers – types and functions of risers, directional solidification – factor affecting and significance, use of exothermic sleeves, bricks, chills and their types, types and uses of filters, computer aided design for gating and risering systems.

Principles of Solidification: Nucleation kinetics, fundamentals of growth, solidification of single-phase alloys, solidification of eutectic alloys, solidification of peritectics. Melting practices and furnaces for ferrous and non-ferrous alloys: Melting practices of Al- alloys, Mg – alloys, Cu – based alloys and Ti- based alloys and SG Iron; Degassing process and methods in Al – alloys, modification treatment in Al- alloys, use of covering fluxes to avoid oxidation; Furnaces used - oil and gas fired furnaces, induction furnaces, vacuum melting and re-melting processes; Principle of working of thermocouples, spectrometers, and C.E. meters – applications; energy saving in melting practices.

Modern molding and core making processes and equipments: Various types of sands used for moulding and core making, testing of sand, high pressure line molding, Dissamatic, chemically bonded sands; shell molding binder, hardener and type of sand used in shell molding, procedure used for making shell sand, plants used, properties and tests on shell sand, stick point strength, advantages and applications; Resin bonded sands, alkyl resins, phenolic resins and furnace sands, cold box method of core making – advantages and applications, ceramic molding, vacuum molding, sand reclamation – importance, methods and plants.

Special Casting processes: Investments casting processes and applications; Continuous casting, principle, processes and applications; Die casting, low pressure / gravity, pressure and squeeze, advantages, limitations and applications, centrifugal casting, calculations of various parameters in
centrifugal casting, die temperature, rotational speeds, advantages, limitations and applications of centrifugal casting, defects in centrifugal casting.

COURSE OUTCOMES:

3. Student able to Design of appropriate casting system to make components in industry.
4. Student able to identify and select suitable casting process to make components in industry.

Reference Books:

1) Principles of Metal Castings - Heine, Loper and Rosenthal (TMH)
2) Principles of Foundry Technology - P.L. Jain (TMH)
8) Mechanization of Foundry Shops – Machine Construction - P.N. Aeksenov (MIR)
9) Fundamentals of Metal Casting Technology - P.C. Mukherjee (Oxford, IBH)

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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COURSE OBJECTIVES:

- To understand the fundamentals of numerical methods, statistical and optimization tools
- To apply the numerical, statistical and optimization concepts and procedure for engineering problems
- To learn basic MATLAB codes for solving numerical and statistical problems


Numerical Eigen solution techniques (Power, Householder, QR methods etc.). Numerical solution of systems of nonlinear algebraic equations; Newton-Raphson method. Numerical integration: Newton-Cotes methods, error estimates, Gaussian quadrature


Introduction to optimization methods: Local and global minima, Line searches, Steepest descent method, Introduction to heuristic techniques. Introduction to MATLAB programming

REFERENCES:

1. Steven C. Chapra, Numerical Methods for Engineering, Mc-Graw Hill Education

COURSE OUTCOMES:
1. Apply the numerical concepts and techniques for manufacturing engineering problems.
2. Understand and apply the statistical techniques in manufacturing processes.
3. Apply optimization tools for manufacturing problems.

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ELECTIVES
PRODUCT & SYSTEM STREAM

PR628 Additive Manufacturing

COURSE OBJECTIVES:

- To understand the importance of time compression technologies
- To selection of appropriate technology for the application
- To explore RP software packages

Introduction- Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry, Classification of RP systems.


Software for RP: STL files, overview of solid view, magics, mimics, magics communicator, etc., internet based softwares, collaboration tools.


REFERENCES:

COURSE OUTCOMES:

1. Understand the importance of time compression technologies
2. Selection of appropriate technology for the application
3. Exposure to RP software packages

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COURSE OBJECTIVES:

- To define the principles of optimum design.
- To apply surface modelling techniques.
- To analyze production systems at operation level.

Basic concepts of CAD - CAD workstation - principles of computer graphics - graphics programming - mechanical drafting package.

Advanced modeling techniques - surface modeling - solid modeling, rendering methods. Graphics and data exchange standards, CAD/CAM data base development and data base management systems.

Principles of optimum design - CAD optimization techniques, design for manufacture and assembly, principles of computer aided engineering, application of CAD, rapid prototyping, concurrent engineering.

Computer aided manufacturing, programming and interface hardware – computer aided process monitoring - adaptive control, on-line search strategies, computer-aided process planning.

Production systems at the operation level - computer generated time standards - machinability data systems - cutting conditions optimization - production planning - capacity planning - shop floor control - computer integrated manufacturing systems, application.

REFERENCES:


COURSE OUTCOMES:

1. Define the principles of optimum design.
2. Apply surface modelling techniques.
3. Analyze production systems at operation level.
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COURSE OBJECTIVES:

1. To apply and interfere the application of statistical methods in manufacturing processes.
2. To identify the causes of process variation through statistical process control.
3. To apply the experimental design concepts in manufacturing process for problem solving.

Review of probability and statistic distributions used in manufacturing processes. Statistical process control and process capability analysis

Mechanical process variation – analyzing the causes and interpreting data

Alternate SPC methods for manufacturing process control

Application of experimental design in manufacturing

Full factorial models, Response surface modeling and process optimization, Analysis of Process robustness, Case studies

REFERENCES:


COURSE OUTCOMES:

1. Apply and interfere the application of statistical methods in manufacturing processes.
2. Identify the causes of process variation through statistical process control.
3. Apply the experimental design concepts in manufacturing process for problem solving.

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COURSE OBJECTIVES:

1. To apply various design rules in manufacturing processes
2. To evaluate the process by design guidelines for optimum design
3. To analyze design alternatives in the manufacture of components


Design for Powder Metallurgy – Design for polymer processing - General design rules for machining - Dimensional tolerance and surface roughness - Design for machining.


REFERENCES:

COURSE OUTCOMES:

1. Apply various design rules in manufacturing processes.
2. Evaluate the process by design guidelines for optimum design.
3. Analyze design alternatives in the manufacture of components.

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COURSE OBJECTIVES:

- To identify the various types of control valves
- To apply PLCs in circuits
- To select appropriate hydraulic and pneumatic circuits


Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram.

Programmable logic control of Hydraulics and Pneumatics circuits, Sensors, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. Electronic drive circuits for various Motors.

Semi automats-automats-transfer lines - automatic assembly - transfer devices and feeders- classifications and applications-job orienting and picking devices- setting of automats and transfer lines.

REFERENCES:

COURSE OUTCOMES:

1. Identify the various types of control valves
2. Apply PLCs in circuits
3. Select appropriate hydraulic and pneumatic circuits.

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COURSE OBJECTIVES:

- To recognize the trends in product development processes
- To execute various phases of product development
- To design eco friendlier products

Product development process – various phases, Reverse engineering and redesigning product development process, Illustrations of product development process, S-curve, new product development.

Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality. Tear Down and Experimentation, product portfolios.

Generating Concepts- Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis, concept selection, technical feasibility, ranking, measurement theory.

Robust design, Design for Manufacture and Assembly, Axiomatic design, TRIZ, Value Engineering, Industrial design, Poka Yoke – Lean principles – Six sigma concepts.

Design for the Environment: DFE methods, life cycle assessment, weighted sum assessment method, techniques to reduce environmental impact – disassembly, recyclability, remanufacturing regulations and standards.

REFERENCES:


COURSE OUTCOMES:

1. Understand the challenges and advancements of product development process
2. Execute various phases of product development
3. Develop environmentally friendly products/processes
## Mapping of Programme Outcomes with Course Outcomes:

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COURSE OBJECTIVES:

1. To understand the principles of various micro and nano manufacturing processes
2. To study various machine tools and techniques
3. To study recent developments in micro and nano manufacturing
4. To understand various measuring techniques used for micro/nano components.


Abrasive flow finishing, magnetic abrasive finishing, magnetorheological finishing, magnetorheological abrasive flow finishing, magnetic float polishing – Hybrid finishing processes - chemo mechanical polishing, electro discharge grinding, electrolytic in process dressing grinding.


Metrology for micro machined components - optical microscopy, white light interferometry, micro CMM, scanning probe microscopy – scanning electron microscope, transmission electron microscope, atomic force microscope-

REFERENCES:

COURSE OUTCOMES:

1. Principles of various micro and nano manufacturing processes
2. Various machine tools and techniques
3. Recent developments in micro and nano manufacturing
4. Various measuring techniques used for micro/nano components.

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COURSE OBJECTIVES:

- To identify the components of a robot
- To program robots for different applications
- To introduce robots in various manufacturing techniques


Robot and its peripherals - sensors, machine vision - image processing & analysis - application of artificial intelligence, voice communication - robot control units - motion controls.


Robot Programming - different languages - expert systems.


REFERENCES:


COURSE OUTCOMES:

1. Identify the components of a robot
2. Program robots for different applications
3. Introduce robots in various manufacturing techniques.
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PR636  Terotechnology

COURSE OBJECTIVES:

- To increase the reliability of a system
- To conduct reliability analysis
- To identify appropriate models for reliability measurement


Component reliability and Hazard Models – Nonlinear hazard model

Redundancy Techniques in System Design- Vibration analysis.

System reliability – Types, Fault Tree Analysis.

REFERENCES:


COURSE OUTCOMES:

1. Increase the reliability of a system.
2. Conduct reliability analysis.
3. Identify appropriate models for reliability measurement.
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COURSE OBJECTIVES:

1. To Learn the overall view of Geometric Dimensioning and Tolerancing.
2. To Learn the Principles of tolerancing and geometrical tolerancing.
3. To Learn the Profile tolerancing and Tolerancing of flexible parts.
4. To Learn the suitable geometrical tolerancing method related to components function, manufacturing and inspection.

(Use of approved design data book is permitted in the examination)

Introduction to Geometric Dimensioning and Tolerancing, Scope, Definitions, and General Dimensioning, General Tolerancing and Related Principles, Symbology, Datum Referencing, Tolerances of Location, Form, Profile, Orientation, and Runout.

Properties of the surface, Principles for tolerancing and geometrical tolerancing- Symbols- Definitions of geometrical tolerances- Tolerance zone- Form of the tolerance zone- Location and orientation of the tolerance zone- Width of the tolerance zone- Length of the tolerance zone- Common tolerance zone- Datums- Axes and median faces- Screw threads, gears and splines - Angularity tolerances and angular dimension tolerances- Twist tolerance.

Profile tolerancing, Tolerancing of cones, Positional tolerancing, projected tolerance zone, Substitute elements, Maximum material requirement, Envelope requirement, least material requirement.

Tolerancing of flexible parts, Tolerance chains (accumulation of tolerances), Statistical tolerancing, respecting geometrical tolerances during manufacturing- Manufacturing influences-Recommendations for manufacturing.


REFERENCES:


COURSE OUTCOMES:

1. Identify the general dimensioning techniques
2. Apply the principles of tolerance in Manufacturing
3. Calculate the optimum material requirement
4. Identify the suitable geometrical tolerancing methods related to components function, manufacturing and inspection.

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PR638  Modelling, Simulation and Analysis

COURSE OBJECTIVES:

- Building of Models with logic
- Develop routines to capture uncertainty in systems
- Modelling and Simulation of Discrete Event Systems


Evaluation Scheme: Term Tests 30  Tutorials and Practical Assignments 20 Final Examination 50 Marks

REFERENCES:


COURSE OUTCOMES:

1. Develop manufacturing models of discrete event systems
2. A generation of uncertainty using random numbers and random variates
3. Perform input, output analysis: Verification and validation of models and optimization.
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PR639 Supply Chain Management

COURSE OBJECTIVES:

- To demonstrate operational purchasing methods and techniques on supplier management and supply in specific business contexts.
- To explain the strategic importance of logistic elements and describe how they affect supply chain management.
- To analyze the creation of new value in the supply chain for customers, society and the environment.

Introduction to supply chain management -Supply Chain Performance: Achieving Strategic Fit and Scope -Supply Chain Drivers and Metrics.

Planning in Supply chain -Demand Forecasting in a Supply Chain -Aggregate Planning in a Supply Chain – Planning and Managing Inventories in a supply chain.


Managing cross-functional drivers in supply chain -Sourcing Decisions in a Supply Chain -Pricing and Revenue Management in Supply Chain-Information Technology in Supply Chain -Coordination in Supply Chain.

Modern Supply chain management -Reverse supply chain strategies –Green and sustainable practices of Supply chain –Supply chain cases.

REFERENCES:

2. V.V. Sople, “Supply Chain Management, text and cases”, Pearson Education South Asia, 2012

COURSE OUTCOMES:

1. Explain the major building blocks, major functions, major business processes, performance metrics, and major decisions in supply chain networks.
2. Summarize the foundation for design and analysis of supply chains and synthesize advanced and specialized concepts, principles and models for operational and strategic improvement.
3. Analytically examine the supply chain of organizations and measure performance improvement.

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ELECTIVES

Manufacturing Management Stream (Common Electives with M.Tech.-Ind. Engg. & Mgmt.)

PR662 Intelligent Manufacturing Systems

COURSE OBJECTIVES:

- To apply various knowledge based techniques
- To practice diagnosis and trouble shooting
- To adopt intelligent system

Basic concepts of Artificial intelligence and expert systems - System Components - System architecture and Data flow – System Operations.

Knowledge based systems - knowledge representation – knowledge acquisition and optimization - Knowledge based approaches to design mechanical parts and mechanisms and design for automated assembly.

Knowledge based system for material selection – Intelligent process planning system. Intelligent system for equipment selection - Intelligent system for project management & factory monitoring.

Scheduling in manufacturing – scheduling the shop floor – Diagnosis & trouble shooting. The role of Artificial Intelligence in the factory of the future – Intelligent systems.

REFERENCES:


COURSE OUTCOMES:

1. Apply various knowledge based techniques.
2. Practice diagnosis and trouble shooting.
3. Adopt intelligent system.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:
COURSE OBJECTIVES:

- To recognize need and trends of Industry 4.0 and Cloud manufacturing
- To understand concepts and technologies supporting Industry 4.0 and Cloud Systems
- To explore challenges and Industrial applications of Industry 4.0 in manufacturing

Various Industrial Revolutions, Compelling Forces and Challenges for Industry 4.0, Comparison of Industry 4.0 Factory and Today’s Factory, Lean Production Systems.

Internet of Things (IoT)- IoT design methods, physical devices and enabling technologies, Industrial Internet of Things (IIoT), Smart Manufacturing.


Introduction to cloud computing and manufacturing- cloud models, cloud manufacturing examples, cloud based manufacturing, Cloud service and platforms for manufacturing.

Industry 4.0 integration with manufacturing systems, Application domains, Case studies on IoT cloud system in manufacturing and other domains

REFERENCES:

COURSE OUTCOMES:

1. Understand trends of Industry 4.0 and cloud manufacturing.
2. Competence on systems and technologies of Industry 4.0 & cloud system.
3. Recognize industrial applications of Industry 4.0 in manufacturing.

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PR668  Sustainable Manufacturing  

COURSE OBJECTIVES:

- To recognize the importance of sustainable manufacturing
- To understand and apply appropriate sustainability tools/techniques
- To explore practical applications of sustainability concepts


Frameworks for measuring sustainability- Indicators of sustainability – Environmental, Economic, Societal and Business indicators - Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment– Corporate Social Responsibility.

REFERENCES:

5. S. Asefa, “The Economics of Sustainable Development”, W.E. Upjohn Institute for

COURSE OUTCOMES:

1. Realize the importance of sustainable manufacturing
2. Exhibit competence on the usage and applicability of sustainability tools
3. Recognize applications of sustainability concepts in various domains

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COURSE OBJECTIVES:

1. To enable the students to understand the methods for project identification and appraisal.
2. To plan and schedule a project with resource and environmental constraints.
3. To develop quantitative methods for project selection, risk assessment, monitoring and control.

Introduction - Project Management: An Overview – Types, Characteristics of Projects – Project life cycle. Identification of investment opportunities - Screening and Selection,


Financial analysis – cash flows for project appraisal- Investment evaluation using capital budgeting techniques - net present value, profitability index internal rate of return, payback period, accounting rate of return

Mathematical Techniques for project evaluation – Linear programming, goal programming, Network technique for Project Management – CPM, PERT, Multiple projects and constraints, scheduling. Performance metrics for project evaluation.

Organization systems for project implementation- Work Breakdown-coordination and control- Project Management Soft wares, Role of AI in project management

REFERENCES:

4. http://nptel.ac.in/courses/110104073/
COURSE OUTCOMES:

1. Understand the process and approaches for executing projects.
2. Develop and analyze quantitative models for project selection and scheduling.
3. Apply engineering and management principles to manage real time projects considering constraints.
4. Apply tools for managing complex projects.
5. Analyse the outcome and offer suggestions for improvement

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COURSE OBJECTIVES:

- To realize the scope of product life cycle management.
- To explore the possibility of Collaborative Product Development and digital manufacturing in practical applications.
- To develop strategy for PLM applications

Introduction to Product Life Cycle Management (PLM): Definition, PLM Lifecycle model, Need for PLM, Opportunities and benefits of PLM, Components and Phases of PLM, PLM feasibility study

PLM Concepts, Processes and Workflow - Characteristics of PLM, Environment driving PLM, PLM Elements, Drivers of PLM, Conceptualization, Design, Development, Validation, Production, Support of PLM.

Collaborative Product Development - Engineering vaulting, product reuse, smart parts, engineering change management, Bill of materials and process consistency, Digital mock-up and prototype development, design for environment, virtual testing and validation, marketing collateral

Digital Manufacturing – PLM Digital manufacturing, benefits manufacturing, manufacturing the first-one, Ramp up, virtual learning curve, manufacturing the rest, production planning

Developing a PLM strategy and conducting a PLM assessment- Strategy, Impact of strategy, implementing a PLM strategy, PLM initiatives to support corporate objectives. Infrastructure assessment, assessment of current systems and applications

REFERENCES:

COURSE OUTCOMES:

1. Recognize the importance of Product Life Cycle Management.
3. Competence to develop PLM strategy and conduct PLM assessment

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PR681  Advanced Optimization Techniques  

COURSE OBJECTIVES:

1. To gain the knowledge of Traditional optimization techniques.
2. To gain the knowledge of Non Traditional optimization techniques.

Classification of Optimization Problems - Optimization Techniques
   Classical Optimization Techniques- Single-Variable Optimization - Multivariable Optimization with No Constraints - Multivariable Optimization with Equality Constraints- Multivariable Optimization with Inequality Constraints- Transportation

REFERENCES:

COURSE OUTCOMES:

1. To learn the Traditional optimization techniques and apply it in engineering field.
2. To learn the Non Traditional optimization techniques and apply it in engineering field.

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