# NATIONAL INSTITUTE OF TECHNOLOGY, TIRUCHIRAPPALLI

## DEPARTMENT OF PRODUCTION ENGINEERING - M. Tech. (Manufacturing Technology)

**Total minimum credits required: 69 (Operative for students from 2020-2021 admission)**

| CODE | Semester 1 | L | T | P | C | CODE | Semester 2 | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PR601 | Advanced Machining Technology | 3 | 0 | 0 | 3 | PR604 | Advanced Tooling and Automated Inspection | 2 | 1 | 2 | 4 |
| PR602 | Advanced Forming Technology | 2 | 1 | 2 | 4 | PR605 | CNC Technology | 3 | 0 | 0 | 3 |
| PR603 | Advanced Welding Technology | 3 | 0 | 0 | 3 | PR606 | Manufacturing Management | 2 | 1 | 0 | 3 |
| ----- | **Elective I** | 3 | 0 | 0 | 3 | ----- | **Elective IV** | 3 | 0 | 0 | 3 |
| ----- | **Elective II** | 3 | 0 | 0 | 3 | ----- | **Elective V** | 3 | 0 | 0 | 3 |
| ----- | **Elective III** | 3 | 0 | 0 | 3 | ----- | **Elective VI** | 3 | 0 | 0 | 3 |
| PR607 | Advanced Machining and Forming Lab. | 0 | 0 | 3 | 2 | PR609 | Automation & CIM Lab. | 0 | 0 | 3 | 2 |
| PR608 | Advanced Casting and Welding Lab. | 0 | 0 | 3 | 2 | PR610 | Process Modelling and Additive Manufacturing Lab. | 0 | 0 | 3 | 2 |
| **Total** | | **17** | **1** | **8** | **22** | **Total** | | **17** | **1** | **6** | **23** |

| CODE | Semester 3 | L | T | P | C | CODE | Semester 4 | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PR638 | Project Work – Phase I | 0 | 0 | 24 | **12** | PR639 | Project Work – Phase II | 0 | 0 | 24 | **12** |

**LIST OF ELECTIVES**

| CODE | Materials & Process Stream | L | T | P | C | CODE | Product & System Stream | L | T | P | C |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PR 611 | Modeling of Manufacturing Processes | 3 | 0 | 0 | 3 | PR628 | Additive Manufacturing | 3 | 0 | 0 | 3 |
| PR 612 | Advances in Polymer matrix Composites | 3 | 0 | 0 | 3 | PR 629 | Computer Aided Design and Manufacturing | 3 | 0 | 0 | 3 |
| PR 613 | Heat Treatment | 3 | 0 | 0 | 3 | PR 630 | Control of Manufacturing Processes | 3 | 0 | 0 | 3 |
| PR 614 | Industrial Welding Applications | 3 | 0 | 0 | 3 | PR 631 | Design for Manufacture | 3 | 0 | 0 | 3 |
| PR 615 | Lasers in Manufacturing | 3 | 0 | 0 | 3 | PR 632 | Manufacturing Automation and Mechatronics | 3 | 0 | 0 | 3 |
| PR 616 | Machine Tool Technology | 3 | 0 | 0 | 3 | PR 633 | Product Design and Development | 3 | 0 | 0 | 3 |
| PR 617 | Manufacturing of Non-metallic Products | 3 | 0 | 0 | 3 | PR 634 | Micro/Nano Manufacturing | 3 | 0 | 0 | 3 |
| PR 618 | Materials Technology | 3 | 0 | 0 | 3 | PR 635 | Robotics | 3 | 0 | 0 | 3 |
| PR 619 | Mechanical Behaviour of Materials | 3 | 0 | 0 | 3 | PR 636 | Terotechnology | 3 | 0 | 0 | 3 |
| PR 620 | Mechanics of Composite Materials | 3 | 0 | 0 | 3 | PR 637 | Tolerance Technology | 3 | 0 | 0 | 3 |
| PR 621 | Non-Destructive Testing | 3 | 0 | 0 | 3 | PR638 | Modeling, Simulation and Analysis | | | | |
| PR 622 | Fabrication of Smart Materials and MEMS | 3 | 0 | 0 | 3 | PR639 | Supply Chain Management | 2 | 1 | 0 | 3 |
| PR 623 | Surface Engineering | 3 | 0 | 0 | 3 | | **Manufacturing management Stream (Common Electives with M.Tech.-Ind. Engg. & Mgmt.)** | 3 | 0 | 0 | 3 |
| PR 624 | Tribology | 3 | 0 | 0 | 3 | PR662 | Intelligent Manufacturing Systems | 3 | 0 | 0 | 3 |
| PR 625 | Processing of Friction Composites | 3 | 0 | 0 | 3 | PR668 | Industry 4.0 and Cloud Manufacturing | 3 | 0 | 0 | 3 |
| PR 626 | Advanced Casting Processes | | | | | PR670 | Sustainable Manufacturing | 3 | 0 | 0 | 3 |
| PR 627 | Computational methods in Manufacturing | | | | | PR674 | Project Management | 3 | 0 | 0 | 3 |
| | | | | | | PR679 | Product Life Cycle Management | 3 | 0 | 0 | 3 |
| | | | | | | PR681 | Advanced optimization techniques | 3 | 0 | 0 | 3 |

**PR601** **Advanced Machining Technology**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

## 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.

Mechanical Processes: Ultrasonic Machining - Water Jet Machining - Abrasive Jet Machining - Abrasive Water Jet Machining - Ice Jet Machining - Magnetic Abrasive Finishing – working principle, merits, demerits and applications.

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:

1. Bhattacharya "Metal Cutting Theory and Practice”, New Central Book Agency (p) Ltd., Calcutta1984.
2. Boothroy .D.G. and Knight. W.A "Fundamentals of Machining and Machine tools", Marcel Dekker, New York, 1989.
3. Hassan Abdel – Gawad El-Hofy "Advanced Machining Processes", McGraw, New York, 2005.
4. Metals Handbook. Vol. 16, Machining. Materials Park; OH: ASM International, 1995.
5. Kalpakjian, S “Manufacturing Process for Engineering Materials”, MA:Addison-Wesley, 1997.
6. Brown, J “Advanced Machining Technology Handbook”, New York: McGraw-Hill, 1998.
7. McGeough, J “Advanced Methods of Machining”, London. New York: Chapman and Hall,

London, 1988.

8. Rumyantsev, E and Davydov, A “Electrochemical Machining of Metals”, Moscow:Mir Publishers, 1984.
9. Xichun Luo and Yi Qin “Hybrid Machining: Theory, Methods, and Case Studies”, Academic press, 2018.

**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.

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | ✓ |
| CO3 | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | ✓ |
| CO4 | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | | | ✓ |

**PR602** **Advanced Forming Technology**

| L | T | P | C |
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| 3 | 0 | 0 | 3 |

## 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 Bassni'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:

1. Hosford W.F and Caddell, R.M, "Metal Forming Mechanics and Metallurgy", Prentice Hall, 1983.
2. W.Johnson&P.B.Mellor "Engineering Plasticity" McGraw Hill.
3. Plasticty Theory, J. Lubliner.
4. Fundamentals of the theory of plasticity, L. M. Kachanov
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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | | ✓ | ✓ | ✓ | | | | | | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ |
| CO3 | ✓ | | ✓ | ✓ | ✓ | | | | | | ✓ |

**PR603** **Advanced Welding Technology**

| L | T | P | C |
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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.

Electron beam welding - Laser beam welding - Hybrid welding - CMT welding – SpinArc GMAW – Tandem GMAW - Activated TIG welding- Hot wire TIG welding- Diffusion bonding - Weld Surfacing & cladding.

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.

Magnetically impelled arc butt (MIAB) welding - Under water welding -Welding of Cu, Al, Ti and Ni alloys – Dissimilar welding of ferrous alloys - processes, difficulties, microstructures, defects and remedial measures -Hydrogen embrittlement – Lamellar tearing – Residual stress – Distortion and its control.

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.
2. H.S.Bawa "Manufacturing Technology-I" Tata Me Graw Hill Publishers New Delhi, 2007.
3. S.V.Nadkami, Modem Arc Welding Technology, Oxford & IBH Publishing Co. Pvt. Ltd.
4. CORNU.J. Advanced welding systems – Volumes I, II and III, JAICO Publishers,1994.
5. LANCASTER.J.F. – Metallurgy of welding – George Alien & Unwin Publishers, 1980
6. Carry B., Modern Welding Technology, Prentice Hall Pvt Ltd., 2002
7. P .L. Jain “Principles of foundry Technology" Tata Mc Graw Hill 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| CO2 | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| CO3 | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | |

**PR604 Advanced Tooling and Automated Inspection**

| L | T | P | C |
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| 2 | 1 | 2 | 4 |

**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:**

1. Fundamentals of Tool Design, Fifth Edition Society of Manufacturing Engineers, 2003
2. Mikell P Groover Fundamentals of Modern Manufacturing: Materials, Processes, and Systems John Wiley and Sons 2012
3. Stanley L. Robinson, Richard Kendall Miller Automated Inspection and Quality Assurance 1989 CRC Press
4. Duc T. Pham and R J Alcock Smart Inspection Systems: Techniques and Applications of Intelligent Vision Academic Press

**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

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | | | | | | | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ |

**PR605** **CNC Technology**

| L | T | P | C |
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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.

Feedback devices– interpolators - tooling for CNC– point-to-point and contouring systems – DNC-Adaptive Control – ACO and ACC systems- graphical numerical control.

Automation – principles – strategies – levels of automation – automated manufacturing systems– devices, drives and control circuits in automation - semi-automats, automats and transfer lines.

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:

1. YoramKoren, "Computer Control of Manufacturing Systems", McGraw Hill Book Co. New Delhi, 1986.
2. Mikell P. Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India, 2009.
3. Radhakrishnan P., "Computer Numerical Control Machines", New Book Agency, Calcutta, 1991
4. Kundra T. K., Rao P. N., and Tiwari N. K., "CNC and Computer Aided Manufacturing", Tata McGraw Hill, New Delhi, 1991.
5. Fitzpatric.M., “Machining and CNC Technology”, McGraw Hill, 2004

## COURSE OUTCOMES:

1. Develop advanced machine language for operating machine tools.
2. Apply computer numerical control techniques for making macro and micro products.
3. Understand cellular manufacturing techniques.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO1 | ✓ | ✓ | | | ✓ | | | | ✓ | | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | ✓ |

**PR606** **Manufacturing Management**

| L | T | P | C |
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| 3 | 0 | 0 | 3 |

## 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:

1. Sunil Chopra, Peter Meindl, “Supply Chain Management: Strategy, Planning and Operations”, Prentice Hall India, 6th Edition, 2016
2. Buffa, Sarin “Modern Production Management”, 8th Edition, John Wiley, 2007.
3. O. Perez, S. Sauceda, 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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO1 | ✓ | | | | | | | | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | | | | | | | |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | |
| CO4 | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | |
| CO5 | ✓ | ✓ | ✓ | | | ✓ | ✓ | | | | ✓ |

**PR607** **Advanced Machining and Forming Lab.**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 3 | 2 |

## 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 with in 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.
4. Measurement of bonding strength of coating using Scratch Tester.
5. Study on the effect of process parameters in Electro-Chemical/Electric-Discharge Machining
6. Laser transformation hardening of ferrous materials.
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.
14. Residual stress analysis of laser beam on plate by using Software.
15. Heat generation due to contact friction by using Software.
16. Construction of FLD and analysis of Forming Limit.
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.
21. Analysis of open die forging for metal.
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:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | ✓ |
| CO3 | ✓ | | ✓ | ✓ | ✓ | | | | | | ✓ |
| CO4 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | | | ✓ |

**PR608** **Advanced Casting and Welding Lab.**

| L | T | P | C |
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| 0 | 0 | 3 | 2 |

## 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.
8. Design and analysis of Gravity Casting process using CAD software.
9. Plastic Injection Molding processes: design and analysis 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 Fricition 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
26. Investigation on Microstructure Analysis of Arc welded ferrous Alloys.
27. Investigation on Microstructure Analysis of Arc welded non Ferrous Alloys.
28. Investigation on weldment region micro hardness using vickers micro hardness tester.
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
31. Investigation on effect of Post weld heat treatment on the Microstructure of 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:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**PR609** **Automation & CIM Lab.**

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| 0 | 0 | 3 | 2 |

## 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
4. Exercise on Electro-hydraulic system: Design, construct and simulation of different Electro-hydraulic circuits for the given applications.
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:

1. Automation & CIM Lab manual.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO1 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
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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.
3. Modeling & simulation of forging/rolling/machining process using a FEA package.
4. Microstructural modelling of machined specimen using Cellular Automata (CA) method.
5. Modelling & Simulation of selective laser melting using Multi-physics software.
6. Selection of Rapid Prototyping Technology.
7. Product development activity – Concept design and Detailed design.
8. Product development activity – Engineering analysis and Prototype development.
9. Life Cycle Assessment using GaBi package.
10. Sustainable Product Development – Developing environmentally friendlier products.

## 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**

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**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

Lagrangean 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. M.Asghar Bhatti “Advanced Topics in Finite Element Analysis of Structures” John Wiley & sons, Inc,2006.
2. Lewis R.W.Morgan, K, Thomas, H.R. and Seetharaman, K.N. The Finite Element Method in Heat Transfer Analysis, John Wiley, 1994.
3. Edward R Champion Jr, “Finite Element Analysis in Manufacturing Engineering”, McGraw Hill, 1992.
4. Prakash M. Dixit, Uday S. Dixit”Modeling of Metal Forming and Machining Processes”, 1st Edition, 2008, Springer Verlog.
5. Lars-Erik Lindgren, “Computational welding mechanics” , 1st Edition, 2007, CRC Press,

**COURSE OUTCOMES:**

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

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

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**PR612 Advances in Polymer Matrix Composites**

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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.

Composite material: Types-MMC-PMC-CMC, Advantages and Disadvantages. Polymer matrix: classification- thermoplastics and thermosetting plastics, types of matrix material, reinforcement material: fiber- particulate- whisker, properties of reinforcements and matrix. Characterization of polymer matrix composites

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.

Joining of PMC: Mechanical fastening of PMC, Chemical bonding of PMC, Joint design, equipment and application methods, Advantages and disadvantages, Applications adhesive bonding. Weldability study on PMC-Friction Welding, Thermal Welding, Electromagnetic Welding-Process-Processing Parameters-Materials-Advantages & Disadvantages and Applications.

Application of Polymers and PMC material: Automotive Industry- Marine Industry- Materials Handling- Chemical Industry- Electrical & Electronics Industry- Aerospace Industry- Biomedical field. Recent advancements in polymeric materials: Polymer Blends, conducting polymer, Polymeric Nanocomposites and Biodegradable Polymer-its Applications. Polymer in health care, Environmental issues concerning polymers and polymer in energy application.

## REFERENCES:

1. Mein Schwartz., “Composite Materials Handbook”, McGraw Hill, 1984
2. “ASM Hand book on Composites”, Volume 21, 2001
3. “Handbook of Plastics Joining- A Practical Guide” Plastics Design Library, 13 Eaton Avenue, Norwich, New York 13815.

4. “Handbook of Polymer Composites for Engineers” by Leonard Hollaway, British Plastics Federation.
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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR613** **Heat Treatment**

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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

Iron - Carbon Equilibrium Diagram: Effect of alloying element on properties of steel and heat treatments. Types and application of heat treatments in manufacturing Industries.

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

Heat Treatment Processes: Annealing – Normalising, Hardenability studies, Jominy end quench test, Grossman's experiments - Tempering, Austempering and Martempering. Thermomechanical treatments.

Surface Modification Techniques: Induction hardening, flame hardening, electron beam hardening and Laser beam hardening. Carburising, nitriding, carbonitriding, CVD and PVD processes, Ion implantation.

Heat Treatment of Non-Ferrous Metals and Specific Alloy steels: Heat treatment of gray irons, white irons (malleabilising) and S.G.irons. Austempering of S.G.Iron. Defects: Defects in heat treated parts, causes and remedy Design for heat treatment.

## REFERENCES:

1. Rajan and Sharma "Heat Treatment Principles and Techniques" – Prentice Hall of India (P) Ltd, New Delhi, 2004.
2. Prabhudev, K H., "Handbook of Heat Treatment of Steels", Tata - McGraw Hill Publishing Co., New Delhi, 2000.
3. VijendraSingh,"Heat Treatment of Metals", Standard Publishers Distributors, Delhi, First edition 1998.
4. American Society for Metals, "Metals Handbook Vol.4", ASM Metals Parks, Ohio, USA, 2001.
5. Karl-Erik Thelning, "Steel and its Heat Treatment", Butterworths London, second edition 1984.
6. Novikov I, "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978.

## 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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR614** **Industrial Welding Applications**

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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 heavy engineering: Boiler manufacture - boiler drum, water wall panels, headers, economizers. Heat exchangers.

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:

1. American Welding Society, 'Guide for Steel Hull Welding', 1992
2. Gooch T. S; 'Review of Overlay Welding Procedure for Light Water Nuclear Pressure Vessels', American Welding Society, 1991
3. Winter Mark H, 'Materials and Welding in Off-Shore Constructions', Elsevier, 1986
4. Welding Institute Canada, 'Welding for Challenging Environments', Pergamon Press, 1996.
5. Mishra, R.S and Mohoney, M W, Friction stir welding and processing, ASM 2007.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR615** **Lasers in Manufacturing**

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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 effectively analyse laser based physical processes and their implications in material processing and manufacturing processes.

Fundamentals of laser –lasing action- properties - spectrum and wavelength –wave length chart-types of laser- modes of operation-continuous mode-pulsed mode-laser components - interaction of laser radiation with materials-long pulse and short pulse interaction.

Laser surface treatment –forms of laser surface treatment-laser transformation hardening - advantages - laser surface melting - laser alloying - laser cladding-co-axial powder feeding-lateral powder feeding-laser texturing-case examples-.

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

Laser cutting –process characteristics-theoretical models of cutting - practical performance-applications - process variations - drilling –single pulse drilling-percussion drilling- trepanning-applications.

Fiber Laser and UV Laser based marking - micromachining solutions - laser shock loading - basics - applications - laser safety - danger - safety limits - eye and skin - class four safety arrangements - electric hazards - fume hazards..

## REFERENCES:

1. William M. Steen, “Laser Material Processing”, Springer Verlag, 2003.
2. M.Young, “Optics and Lasers”, Springer, 1993.
3. K.Thyagarajan, Ajoy K.Ghatak, “Lasers, Theory and Applications”, Plenum Press, 1981.
4. J.F. Reddy, “Industrial Applications of Lasers”, Academic Press, New York, 1978.
5. S. S. Charschan, “Lasers in Industry”, Wiley & Sons Inc., 1974.
6. Michael Bass, “Laser Materials Processing”, Elsevier Science, 1983.

## 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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR616** **Machine Tool Technology**

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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.

Types of drives for machine tool – step and stepless – speed and feed mechanisms – kinematic diagrams. Typical examples for drives in advanced machine tools.

Machine tool vibration – types - effect of undeformed chip thickness variations, rake and clearance angle variations - stability of cutting operation - regenerative chatter - testing of machine tools for alignment and accuracy - standard test charts.

## REFERENCES:

1. Sen and Bhattacharya, “Principles of Machine Tools”, New Central Book Agencies, 1975.
2. Boothroyd,G., “Fundamentals of Metal Machining and Machine Tools”, McGraw Hill, 1985.
3. Acherkan,, “Machine Tool Design”, Vol. 2 & 3, MIR Pub, 1973.

## 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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**PR617** **Manufacturing of Non-Metallic Products**

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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

Introduction to engineering materials – properties of non-metals - Polymers - classification - Thermoplastics and thermosetting plastics - Thermoforming processes - compression and transfer molding - injection molding - extrusion - blow molding - calendaring – reaction injection molding – rotational molding - lamination and pultrusion.

Rubber - additives - applications. Stages in raw rubber and latex rubber technology - Processing of rubbers –Manufacturing techniques - tires - belts - hoses - foot wears - cellular products - cables. Manufacture of latex based products.

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.

Ceramics - classification - traditional ceramics - structural ceramics - fine ceramics - bio ceramics - ceramic super conductors. Ceramic powder preparation - Ceramic processing techniques - hot pressing - hot isostatic pressing (HIP) - Sintering - injection molding - slip casting - tape casting - gel casting - extrusion.

Composites – types and manufacturing methods: hand lay-up – autoclaving - filament winding - pultrusion - compression molding – preparation of molding compounds and prepregs - sheet molding - casting - solid state diffusion - cladding - HIP - liquid metal infiltration – sintering and its types - knitting - braiding.

## REFERENCES:


1. Manufacturing Processes for Engineering Materials : S. Kalpakjian, 5th edition Pearson , 2009
2. Plastic Materials and Processing: A. Brent Strong, Prentice Hall, 2006
3. Composite Materials: Engineering and Science: F.L. Mathews and R.D. Rawlings, CRC press, 1999.
4. Premamoy Ghosh, Polymer Science and Technology – Plastics, Rubber, Blends, and Composites, 3rd Edition, Mcgraw hill, 2011.
5. ASM Handbook, Vol. 21 Composites, 2001 Lubin, Handbook of Composites, Springer, 1st Edition, 1982.


## 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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR618** **Materials Technology**

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## 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:

1. George Krauss, "Steels; Processes, Structure& Performance", ASM International, The Materials Information Society, 2005
2. Narayanasamy R., "Metal Forming Technology", Ahuja publications, New Delhi, 2000.
3. S.Kalpakjian, "Manufacturing Processes for Engineering Materials", Addison Wesley Pub. Co., 1997.

## 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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**PR619** **Mechanical Behaviour of Materials**

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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:


1. William F. Hosford, Mechanical Behaviour of Materials, Cambridge University Press, New York, USA, 2005.
2. Marc A. Meyers and Krishan Kumar Chawla, Mechanical Behaviour of Materials, 2nd revised eds, Cambridge University Press, New York, USA, 2008.
3. Dieter, G. E., “Mechanical Metallurgy”, 3rd Ed., McGraw Hill. 1988
4. Courtney, T.H., “Mechanical Behavior of Materials”, 2nd Ed., McGraw Hill. 1990
5. Meyers, M.A. and Chawla, K.K., “Mechanical Behavior of Materials”, Prentice Hall. 1999
6. R.W.K., “The Plastic Deformation of Metals”, Edward Arnold.
7. D.W.A. Rees, Basic Engineering Plasticity, Elsevier India, New Delhi, 2008.
8. John D. Verhoeven, Fudamentals of Physical Metallurgy, Wiley, 1975.
9. Robert E. Reed-Hill, Physical Metallurgy Principles, 2nd Editions, East-West Press Pvt. Ltd, New Delhi, 2008.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR620** **Mechanics of Composite 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.

Micro and Macro mechanics of a lamina**:** four elastic moduli – Rule of mixture, ultimate strengths of unidirection lamina - Hooke's law - number of elastic constants - Two – dimensional relationship of compliance & stiffness matrix.

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:

1. Mein Schwartz, "Composite Materials Hand Book", McGraw Hill, 1984.
2. Autar K. Kaw, "Mechanics of Composite Materials", CRC Press, 1994.
3. Rober M Joness, "Mechanics of Composite Materials", McGraw HIll,1982.

## 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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**PR621** **Non-Destructive Testing**

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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 indictions 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:

1. American Metals Society, "Non-Destructive Examination and Quality Contro!"Metals Hand Book, Vol. I 7, 9th Ed, Metals Park, OH, 1989.
2. Krautkramer, Josef and Hebert Krautkramer, "Ultrasonic Testing of Materials", 3rd Ed, Newyork, Springer-verlag, 1983.
3. Goswami,”Thin film fundamentals”, New age international (P) Ltd. Publishers, New Delhi, 1996
4. Birchan, D, "Non Destructive Testing", Oxford University Press, 1977.

## 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**

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## 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

Introduction to smart materials and MEMS: an overview- scaling issues in MEMS -Micro sensors – Micro actuators – Micro systems – Examples of smart systems.

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.

Mechanics of materials- Stresses and deformation: bars and beams - Micro device suspensions: lumped modeling -Residual stress and stress gradients - Thermal loading; bimorph effect - Vibrations of bars and beams - Gyroscopic effect.

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.
3. S.D. Senturia, Microsustem Design, Kluwer Academic Publishers, 2001.
4. Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, McGraw Hill, 2002.
5. V.K. Varadan, K.J. Vinoy, and S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, Wiley, 2006.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO3 | ✓ | ✓ | ✓ | | | | | | | | |

**PR623** **Surface Engineering**

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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- Principles, equipment and technologies”, CRC Press, 1999.
2. Lech Pawlowski, "The Science and Engineering of Thermal Spray Coatings", 2nd Edition, John Wiley & Sons, 2008.
3. William M. Steen, Jyotirmoy Mazumder, “Laser Material Processing”, 4th Edition, 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR624** **Tribology**

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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.

Industrial significance of tribology - Strength and deformation properties of solids – physiochemical characteristics of solid surfaces –fracture-modes of fracture- ductile-brittle-Analysis of surface roughness - measurement.

Friction - classification - Adhesion theory of friction - Elastic, plastic and visco - elastic effects in friction - rolling friction - friction of materials - alloys - ceramics - polymers - Interface temperature of sliding surfaces - measurement.

Wear - forms of wear-abrasive wear – adhesive wear - erosive wear -cavitation wear - corrosive wear-oxidative wear- fatigue wear - melting wear - diffusive wear – mechanisms - wear of nonmetallic materials.

Lubrication –types of lubrication-hydro dynamic lubrication - Reynolds equation – hydrostatic lubrication - bearing analysis – elastohydrodynamic lubrication - solid lubrication – boundary lubrication.

Micro/nano tribology - Measurement techniques - Surface Force Apparatus (SFA) - Scanning Probe Microscopy - Atomic Force Microscopy (AFM)-Nano-mechanical Properties of Solid Surfaces and Thin Films - Computer Simulations of Nanometer-Scale Indentation and Friction.

## REFERENCES:

1. I.M. Hutchings, “Tribology: Friction and Wear of Engineering Materials”, Elsevier Limited, 1992.
2. G. W. Stachowiak, A. W. Batchelor, “Engineering Tribology”, Elsevier Limited, 2005.
3. K.C. Ludema, “Friction, wear, lubrication: A text book in tribology”, CRC Press, 1996.
4. Bharat Bhushan, “Principles and applications of tribology”, John Wiley & Sons, 1999.
5. Bharat Bhushan, “Nanotribology and Nanomechanics: An Introduction”, Springer, 2008.

**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:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO3 | ✓ | ✓ | | | ✓ | | | ✓ | ✓ | ✓ | |

**PR625** **Processing of Friction Composites**

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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.

Introduction and Classification of Friction Materials: Introduction- Friction- Types of Friction- Laws of friction- Wear- Types of Wear- Mechanism. Friction Materials: Definition- Broad Classification- Organic Friction Materials- Ceramic Friction Materials- Sintered Friction Materials- Application oriented Friction Composites & Types-OE and aftermarket products

Ingredients & Manufacturing: Raw Materials- Classification of raw materials: Fillers, Binders, Friction Modifiers, Structural Reinforcement- Characteristics of raw materials- Laws governing the choosing of raw materials- Manufacturing Process involved in the development of composites- Case studies on the issues faced during the manufacturing and quality inspection of manufacturing component

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:

1. ASM Handbook, Friction, Lubrication, and Wear Technology, Volume 18, 1992, USA.
2. Peter J.Blau, Friction Science and Technology- From Concepts to Applications, Second Edition, 2009, CRC Press, USA.

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.
5. K. L. Sundarkrishnaa, Friction Material Composites: Materials Perspective, 2013, Springer, ISBN: 3642334504.

**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.

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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| CO4 | | | | | | | | | ✓ | ✓ | | |

**PR626** **Advanced Casting Processes**

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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

Trends & scope in casting Industry: Position of casting industry worldwide and in India, analysis of data in respect of production and demand, recent trends in quality specifications like dimensional accuracy, surface finish and property requirements, specifications, properties and applications of modern cast alloys- SG iron. Al – alloys, Mo- alloys, Ti – alloys.

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)
4) Advanced Pattern Making – Cox I.I. (The Technical Press, London.)
6) Metal Castings – Principles & Practice - T.V. Ramana Rao. (New Age International Pvt. Ltd. Publishers.)
8) Mechanization of Foundry Shops – Machine Construction - P.N. Aeksenov (MIR)
9) Fundamentals of Metal Casting Technology - P.C. Mukherjee (Oxford, IBH)
10) Foundry Engineering – Taylor, Fleming & Wulff (John Wiley)

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

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**PR627 Computational Methods in Manufacturing**

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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

Review of ODEs; Laplace & Fourier methods, series solutions, and orthogonal polynomials. Sturm-Lowville problem. Review of 1st and 2nd order PDEs. Linear systems of algebraic equations. Gauss elimination, LU decomposition etc., Matrix inversion, ill-conditioned system

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

Numerical solution of ODEs: Euler, Adams, Runge-Kutta methods, and predictor-corrector procedures; stability of solutions; solution of stiff equations. Solution of PDEs: finite difference techniques.

Probability and Statistics – Probability Distribution, Bays Theorem, Parameter Estimation, Testing of Hypothesis, Goodness of Fit.

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
2. Schilling R.J and Harris S L, “Applied Numerical Methods for Engineering using MatLab and C”, Brooks/Cole Publishing Co., 2000.
3. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press
4. Hines, W.W and Montogomery, “Probability and Statistics in Engineering and Management Studies”, John Willey, 1990.
5. Deb Kalyanmoy, “ Optimization for Engineering Design: Algorithms and Examples” Prentice-Hall of India Pvt.Ltd, 10th edition, 2009

## 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.

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

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**ELECTIVES**

**PRODUCT & SYSTEM STREAM**

**PR628 Additive Manufacturing**

| L | T | P | C |
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**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.

Principle, process parameters, process details and applications of various RP processes - Stereo lithography systems, Laser Sintering, Fused Deposition Modeling, Laminated Object

Manufacturing, Solid Ground Curing, Laser Engineered Net Shaping, 3D Printing, Laser Melting, Cladding.

Rapid Tooling: Indirect rapid tooling Direct rapid tooling , soft tooling Vs hard tooling, Rapid Manufacturing Process Optimization- Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation.

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

RP Technology selection, Decision Making, Life Cycle Assessment of RP processes, Sustainability issues.

**REFERENCES:**

1. Pham D T and Dimov S S, "Rapid Manufacturing", Verlag, 2001.
2. Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME, 1996.
3. Terry Wohlers, "Wohlers Report 2001", Wohlers Associates, 2008.
4. Prasad H and Badrinarayanan, K S, “Rapid Prototyping and Tooling”, SPI-Pageturners, Bangalore, India, 2013.

## COURSE OUTCOMES:

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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | ✓ |

**PR629 Computer Aided Design and Manufacturing**

| L | T | P | C |
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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:

1. Radhakrishnan P & Kothandaraman C.P, “Computer Graphics and Design”, Dhanpat Rai& Sons, 1990.
2. Groover M P, “Automation, Production System and Computer Aided Manufacture”, Prentice Hall, 1984.
3. William M Newman & Robert Sproul, “Principle of Interactice Computer Graphics”, McGraw Hill, 1984.
4. Ibrahim Zeid, “CAD/CAM Theory and Practice”, McGraw-Hill, 1991

## COURSE OUTCOMES:

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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR630** **Control of Manufacturing Processes**

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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:

1. Montgomery, Douglas C. Introduction to Statistical Quality Control. 5th Ed. New York, NY: Wiley, 2004.
2. Montgomery, Douglas C. Design and Analysis of Experiments. 5th Ed. New York, NY: Wiley, 2004.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR631** **Design for Manufacture**

| L | T | P | C |
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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

Introduction – Need identification - Design process - General Design rules for manufacturability – DFX - basic principles for economical production - creativity in design. Materials: Selection of materials for design developments in material technology - criteria for material selection – selection of material shapes.

Review of various manufacturing processes, design for casting - general design considerations for casting - casting tolerances – product design rules for sand casting – Design for bulk deformation processes – Design for sheet metal processes.

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

Design for assembly - Review of assembly processes – Design for liquid state welding – Design for solid state welding – Design for soldering and brazing – Design for adhesive bonding – Design for joining of polymers - design for heat treatment.

Design for Reliability and Quality – failure mode effect analysis – Design for quality – Deishg for reliability – Approach to robust design – Design for optimization – Case studies - Redesign for manufacture and case studies: Identification of uneconomical design - Modifying the design.

## REFERENCES:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2nd Ed. 2000.
3. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst & Winston Ansthony Knight/CRC Press/2010.
4. James G. Bralla, "Hand Book of Product Design for Manufacturing", McGraw Hill Co, 1986.
5. Design for Manufacturing-Carrado poli-Elsevier Science and Technology Books-2001.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
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**PR632 Manufacturing Automation and Mechatronics**

| L | T | P | C |
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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

Need for Automation, Hydraulic & Pneumatic system Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatics system – Selection criteria. Hydraulic system components selection and specification-characteristics – Linear actuator– construction. Reservoir capacity, heat dissipation, accumulators - standard circuit symbols, circuit (flow) analysis. Direction, flow and pressure control valves-operating-characteristics-electro hydraulic servo valves-types, characteristics and performance.

Typical industrial hydraulic circuits-Design methodology – Ladder diagram-cascade, method- truth table-Karnaugh map method-sequencing circuits-combinational and logic circuit.

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:

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
2. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
3. Dudbey.A.Peace, Basic Fluid Power, Prentice Hall Inc, 1967
4. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979
5. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978.
6. W.Bolton, Mechatronics, Electronic control systems in Mechanical and ElectricaEngineering Pearson Education, 2003.
7. Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994.

## COURSE OUTCOMES:

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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | | | | ✓ | | |

**PR633** **Product Design and Development**

| L | T | P | C |
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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:

1. 1.Kevin Otto and Kristin Wood, —Product Design – Techniques in Reverse Engineering and New Product Developmentll, Pearson Education, 2004.
2. 2.Karl T Ulrich and Steven Eppinger, —Product Design and Developmentll, McGraw Hill, 2011, Fifth Edition.

## 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:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR634** **Micro/Nano Manufacturing**

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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.

Introduction to meso, micro and nano manufacturing- miniaturization and applications – micro-manufacturing – classification – micro-machining: concepts and significance-theory of micro-machining – chip formation -size effect in micro-machining.

LIGA, micro-stereolithography – micro-turning, micro-drilling, micro-milling, diamond turn machining - electric discharge micro-machining-ultrasonic micro-machining- laser beam micro-machining - elastic emission micro machining – focused ion beam micro-machining.

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.

Introduction – classification – principles, advantages limitations and applications-stereolithography – selective laser sintering – FDM, SGC, LOM, 3D printing - Surface modification techniques: sputtering-CVD-PVD-plasma spraying technique - diffusion coatings - pulsed layer deposition.

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

## REFERENCES:

1. Jain, V.K “Introduction to Micro-machining”, Narosa publishing house, ISBN: 978-81-7319-915-8, 2010.
2. Jain, V.K, “Micro-manufacturing Processes”, by CRC Press, ISBN: 9781439852903, 2012.
3. Madou, M.J., “Fundamentals of Micro-fabrication: The science of miniaturization”, CRC Press, 2006.
4. Mcgeoug.J.A., “Micromachining of Engineering Materials”, CRC Press, 2001.
5. Kalpakjian.S, “Manufacturing Engineering and Technology”, Pearson Education, 2001

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO 4 | | ✓ | | | | ✓ | | | | ✓ | ✓ |

**PR635** **ROBOTICS**

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## COURSE OBJECTIVES:

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

Fundamentals of robotics – wrists design - end effectors – actuators - modular robots.

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

Robot kinematics - homogeneous transformations - forward & inverse kinematics - problems of dynamics - differential relationships - motion trajectories - dynamics of a robot control of single & multiple link robot - static force analysis.

Robot Programming - different languages - expert systems.

Robot applications in manufacturing - material transfer & machine loading/unloading - processing operations – inspection - automation - robot cell design – control – recent developments and special applications-Micro & Bio robotics.

## REFERENCES:

1. Richard D Klafter, Thomas A Chmielewski & Michael Negin, “Robotic Engineering – An Integrated Approach”, Prentice Hall, 1994.
2. Deb, S.R., “Robotic Technology and Flexible Automation”, Tata McGraw Hill, 1994.
3. Fu & Gonzales, “Industrial Robotics”, Tata McGraw Hill, 1988.

## COURSE OUTCOMES:

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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO 3 | ✓ | | | ✓ | | | | ✓ | ✓ | | |

**PR636** **Terotechnology**

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## COURSE OBJECTIVES:

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

Basic Concepts of reliability –Reliability and Quality –Failures and Failure modes – Causes of failures and unreliability- Maintainability and Availability- Mathematical Expressions - Laplace Transform application in reliability.

Reliability analysis – Mathematical models – Designing for higher reliability– Reliability and Cost - Failure Data Analysis –MTTF in integral form- Numerical analysis.

Component reliability and Hazard Models – Nonlinear hazard model

Redundancy Techniques in System Design- Vibration analysis.

System reliability – Types, Fault Tree Analysis.

## REFERENCES:

1. Srinath.L.S, "Reliability Engineering", Affiliated East West Press Pvt. Ltd., 1991.
2. Collacott,R.A. "Mechanical Fault Diagnosis & condition monitoring", Chapman and Hall London, 1977.
3. Balagurusamy.E, "Reliability Engineering", Tata McGraw- Hill Publishing Company Limited, New Delhi, 1984.
4. Birolini.A, "Reliability Engineering: Theory and Practice", Springer-Verlag Publishers, Germany, 2004, Fourth Edition.

## COURSE OUTCOMES:

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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR637** **Tolerance Technology**

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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

General geometrical tolerances, Tolerancing principles, Inspection of geometrical deviations, Function, manufacturing, and inspection related geometrical tolerancing, Examples of geometrical tolerancing, Tolerancing of edges, ISO Geometrical Product Specifications (GPS).

## REFERENCES:

1. Gene R. Cogorno “Geometric Dimensioning and Tolerancing for Mechanical Design”, McGraw-Hill,2006

2. Georg Henzold “Geometrical Dimensioning and Tolerancing for Design, Manufacturing and Inspection-A Handbook for Geometrical Product Specification using ISO and ASME Standards”, Elsevier, Second edition
3. Bryan R. Fischer “Mechanical Tolerance Stackup and Analysis” Advanced Dimensional Management, Sherwood, Oregon, U.S.A., Marcel Dekker ,Inc.
4. ASME “Dimensioning and Tolerancing”, Y14.5M-1994 [REVISION OF ANSI Y14.5M-1982 (RI98811)]

**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.

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO3 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| CO4 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**PR638 Modelling, Simulation and Analysis**

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**COURSE OBJECTIVES:**

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

Introduction to systems and modelling Discrete and continuous system - Monte Carlo Simulation. Simulation of Single Server Queuing System Simulation of a manufacturing shop Simulation of Inventory System
Random number generation, properties - Generation of Pseudo Random Numbers Tests for Random Numbers
Random variates-Inverse Transform Technique –Direct Transform Techniques Convolution Method Acceptance Rejection – Routines for Random Variate Generation Testing -Analysis of simulation data-Input modelling Verification and validation of simulation models – output analysis for a single model.
Simulation languages and packages Case studies in WITNESS; FLEXSIM, ARENA, SIMQUICK Simulation based optimization-Modelling and Simulation with Petrinets Case studies in manufacturing systems

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

**REFERENCES:**

1. Jerry Banks & John S.Carson, Barry L Nelson, “Discrete event system simulation” ,Prentice Hall
2. Law A.M, “Simulation Modelling and Analysis”, Tata Mc Graw Hill
3. NarsinghDeo, “System Simulation with Digital Computer”, Prentice H
4. Geoffrey Jordon, “System Simulation”, Prentice hall India Ltd

**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.

**MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR639** **Supply Chain Management**

| L | T | P | C |
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**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.

Designing the Supply chain network –Distribution networks –Transportation networks –Network Design in Supply chain, Network Design in an Uncertain Environment - supply chain optimization.

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:**

1. Sunil Chopra And Peter Meindl, “Supply Chain Management, strategy, planning, and operation”6/e –PHI, second edition, 2014

2. V.V.Sople, “Supply Chain Management, text and cases”, Pearson Education South Asia,2012
3. Janat Shah, “Supply Chain Management, text and cases”, Pearson Education SouthAsia,2009
4. Balkan Cetinkaya, Richard Cuthbertson, Graham Ewer,“Sustainable Supply Chain Management: Practical ideas for moving towards best practice”, Springer, 2011
5. Jeremy F.Shapiro, Thomson Duxbury, “Modeling the Supply Chain”, 2002.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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## ELECTIVES

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

**PR662 Intelligent Manufacturing Systems**

| L | T | P | C |
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### 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 mechansims 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:

1. Kenneth R.Baker, “Introduction to sequencing and scheduling”, John Wiley & Sons, New York, 2000.
2. Richard W. Conway, William L.Maxwell and Louis W. Miller, “Theory of Scheduling”, Dover Publications, 2003.

### 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:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR668 Industry 4.0 and Cloud Manufacturing**

| L | T | P | C |
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**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.

Cyberphysical Systems, Support System for Industry 4.0, Cyber Security, Collaborative Platform and Product Lifecycle Management, Artificial Intelligence, Big Data and Predictive analytics.

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:**

1. Gilchrist, A. (2016). Industry 4.0: the industrial internet of things. (1st ed.), New York, NY: Apress.
2. Garbie, I. (2016). Sustainability in manufacturing enterprises: Concepts, analyses and assessments for industry 4.0. (1st ed.), Switzerland: Springer International Publishing.

3. T. Erl, Z. Mahmood, and R. Puttini (2013), Cloud Computing: Concepts, Technology & Architecture. (1st ed.), Prentice Hall.
4. Velte, A. T., Velte, T. J., Elsenpeter, R. C., & Elsenpeter, R. C. (2009). Cloud computing: a practical approach. (1st ed.) New York: McGraw-Hill.

## 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.

### MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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**PR668** **Sustainable Manufacturing**

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## COURSE OBJECTIVES:

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

Concepts of sustainability and sustainable development – Need for sustainable development - Components of sustainability- Social, Economic, Environmental dimensions - Linkages between technology and sustainability - Sustainable Manufacturing –Scope, Need and Benefits.

Tools and Techniques of Sustainable Manufacturing – Environmental Conscious Quality Function Deployment, Life cycle assessment, Design for Environment, R3 and R6 cycles, Design for Disassembly -Sustainable Product Development – Various Phases.

EIA Methods –CML, EI 95 and 99, ISO 14001 EMS and PAS 2050 standards, Environmental Impact parameters - Interactions between energy and technology and their implications for environment and sustainable development.

Design for recycling – Eco friendly product design methods – Methods to infuse sustainability in early product design phases – Multi-Criteria Decision Making in Sustainability.

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:

1. G. Atkinson, S. Dietz, E. Neumayer, — “Handbook of Sustainable Development”. Edward Elgar Publishing Limited,2008.
2. D. Rodick, “Industrial Development for the 21st Century: Sustainable Development Perspectives”, UN New York,2007.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A., “An Introduction to Sustainable Development”, Earthscan, London, 2008.
4. P. Lawn, “Sustainable Development Indicators in Ecological Economics”, Edward Elgar Publishing Limited, 2006
5. S. Asefa, “The Economics of Sustainable Development”, W.E. Upjohn Institute for

Employment Research, 2005.

## 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

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR674** **Project Management**

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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,

Project Appraisal,Market and demand analysis- market survey-demand forecasting methods-Technical analysis – manufacturing process, materials-product mix, plant location-project charts and layouts.

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:

1. Prasanna Chandra, “Projects – Planning, Analysis, Financing, Implementation and Review”, Tata McGraw Hill,8th Ed, 2017
2. S.Choudry “Project Management”, ”, Tata McGraw Hill,5th Ed, 1995
3. Mike Field and Laurie Keller, “Project Management”, Thompson Business press, 2002
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

### MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO5 | ✓ | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | ✓ |

**PR679** **Product Life Cycle Management**

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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:

1. Antti Saaksvuori, AnselmiImmonen, “ Product Lifecycle Management”, Springer, 2005.
2. John Stark, “Product lifecycle management: 21st century paradigm for product realization”, Springer 2006 London, 3rd printing -2006. 441 pp., ISBN: 1-85233-810-5.
3. Michael Grieves, “Product lifecycle management: Driving the next generation of Lean thinking”, McGraw-Hill, 2006.
4. Kari Ulrich and Steven D. Eppinger, “Product Design & Development”, McGraw Hill, 5th Edition, 2011

## COURSE OUTCOMES:

1. Recognize the importance of Product Life Cycle Management.
2. Realize potential for Collaborative Product Development and digital manufacturing in contemporary manufacturing applications.
3. Competence to develop PLM strategy and conduct PLM assessment

### MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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**PR681** **Advanced Optimization Techniques**

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**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
Nonlinear Programming I: One-Dimensional Minimization Methods - Unimodal Function, ELIMINATION METHODS-Unrestricted Search -Exhaustive Search - Dichotomous Search- Interval Halving Method-Fibonacci Method- Golden Section Method, INTERPOLATION METHODS - Quadratic Interpolation Method - Cubic Interpolation Method -Direct Root Methods -Newton Method-Quasi-Newton Method -Secant Method
Nonlinear Programming II: Unconstrained Optimization Techniques -DIRECT SEARCH METHODS -INDIRECT SEARCH (DESCENT) METHODS, Nonlinear Programming III: Constrained Optimization Techniques- DIRECT METHODS-INDIRECT METHODS , Geometric Programming , Dynamic Programming , Integer Programming -INTEGER LINEAR PROGRAMMING - Stochastic Programming.
Modern Methods of Optimization - Genetic Algorithms -Simulated Annealing -Particle Swarm Optimization -Ant Colony Optimization -Optimization of Fuzzy Systems - Neural-Network-Based Optimization, Practical Aspects of Optimization

**REFERENCES:**

1. Kalyanmoy Deb, Optimization for Engineering design – algorithms and examples. PHI, New Delhi, 1995.
2. Singiresu S.Rao, “Engineering optimization – Theory and practices”, John Wiley and Sons, 1998.
3. Garfinkel, R.S. and Nemhauser, G.L., Integer programming, John Wiley & Sons, 1972.

## 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.

## MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 |
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| CO2 | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |