# COLLEGE OF ENGINEERING, PUNE

**(An Autonomous Institute of Govt. of Maharashtra)**

## DEPARTMENT OF PRODUCTION ENGINEERING AND INDUSTRIAL MANAGEMENT

## CURRICULUM STRUCTURE AND DETAILED SYLLABUS

# M.Tech. Production (Manufacturing Engineering and Automation)

**(Effective From AY 2015-16)**

## Vision

**The *vision* of the Department of Production Engineering and Industrial Management is:**

***To be recognized as an innovative and distinguished center, a preferred provider of Production Engineering students with interdisciplinary education, nurturing research & development and entrepreneur skills among students.***

## Mission

**The *mission* of the Department of Production Engineering and Industrial Management is:**

- Foster, create and develop capacity amongst students to become future leaders in academia, government, industries and entrepreneurial pursuit through a rigorous curriculum of theory and application that develops the ability to solve problems individually and in teams.
- To keep abreast with latest development in academics/industry and continuously upgrade the skill sets of all involved.
- Create knowledge of fundamental principles and innovative technologies through learning, teaching and research in multi-disciplinary domains, focusing on Project Management, Manufacturing, Automation and Mechatronics.
- To provide career guidance for higher education and to facilitate academics - industry interaction.
- To strengthen global collaboration and inculcate research aptitude amongst students and faculty.
- Strive continuously to pursue excellence in research while consciously meeting the expectations of the people it serves with a deep awareness of ethical responsibilities and human values.

## Program Education Objectives (PEOs):

**PEO1:** Advance professionally as a result of his/her ability to solve complex technical problems and to work in multidisciplinary teams on problems whose solutions lead to significant societal benefits.

**PEO2:** Demonstrate professional engineering competence and compete successfully using principles of manufacturing and time and quality management in the design and manufacture of products and services.

**PEO3:** Make scholarly contributions to knowledge as demonstrated by publishing papers and/or technical reports, applying for patents, delivering effective conference presentations, and/or contributing to innovative leadership articles, advance professionally and/or pursue higher education and /or turn entrepreneur.

**PEO4:** Demonstrate a commitment to the community and the profession through involvement with community and/or professional organizations and/or make contributions towards society's greater good and prosperity by exhibiting ethical attitude, life skill, team work in their profession and adapt to current trends by engaging in lifelong learning.

## Program Outcomes (POs):

On successful completion Graduates will demonstrate:

**PO1:** An ability to apply knowledge of mathematics and engineering.

**PO2:** An ability to apply knowledge of manufacturing, material science, to solve the real life problems and to increase the productivity.

**PO3:** An ability to design and conduct and develop experiments, as well as to analyze and interpret the data and optimize the process.

**PO4:** An ability to design a system, component, or process to meet desired needs subject to technical, economical and environmental constraints.

**PO5:** An ability to function on multi-disciplinary teams and familiar with organizational behavior and management.

**PO6:** Ability to identify, formulate, and solve manufacturing engineering problems with advance tools and techniques leading to sustainable development of industry and society.

**PO7:** An understanding of professional and ethical responsibility.

**PO8:** An ability to think, listen and communicate effectively verbally and written.

**PO9:** An understanding of the impact of engineering solutions and industrial safety in a global and societal context.

**PO10:** Recognition of the need for, and ability to engage in healthy competition, lifelong learning and knowledge of contemporary issues.

**PO11:** An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

# DEPARTMENT OF PRODUCTION ENGINEERING AND INDUSTRIAL MANAGEMENT

## M. Tech. Production (Manufacturing Engineering and Automation)

## Effective from A. Y. 2015-16

### M. Tech. (Production) Curriculum Structure
**Specialization: Manufacturing Engineering and Automation**
**(w. e. f. 2015-16)**

### List of Abbreviations

OEC- Institute level Open Elective Course
PSMC – Program Specific Mathematics Course
PCC- Program Core Course
DEC- Department Elective Course
LLC- Liberal Learning (Self learning) Course
MLC- Mandatory Learning Course (Non-credit course)
LC- Laboratory Course

**Semester I**

| Sr. No. | Course Type/Code | Course Name | Teaching Scheme | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | OEC<br>PE(ILE)-15004 | Open Elective Course<br>Project Planning and Control<br>Robot Dynamics and Analysis | 3 | - | - | 3 |
| 2. | MA-15005 | Experimental Design, Data Analysis and Quality Control | 3 | - | - | 3 |
| 3. | PME-15001 | Robotics and Manufacturing Automation | 2 | 1 | - | 3 |
| 4. | PME-15002 | Advanced Machine Tool Design | 3 | - | - | 3 |
| 5. | PME-15003 | Additive Manufacturing Processes, Machines and Applications | 3 | - | - | 3 |
| 6. | PME-15004 | Advanced Manufacturing Laboratory-I | - | 1 | 2 | 2 |
| 7. | MA-15007 | Experimental Design & Data Analysis Laboratory | - | - | 2 | 1 |
| 8. | ML-15001 | Research Methodology | 1 | - | - | 0 |
| 9. | ML-15002 | Humanities | 1 | - | - | 0 |
| | | **Total** | **16** | **2** | **4** | **18** |

**Semester II**

| Sr. No. | Course Code/Type | Course Name | Teaching Scheme | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | PME-15005 | Advanced Materials and Processing | 3 | - | - | 3 |
| 2. | PME-15006 | Manufacturing Systems Design and Optimization | 3 | - | - | 3 |
| 3. | PME-15007 | Advanced Manufacturing Technology | 3 | - | - | 3 |
| 4. | PME-15008 | Metrology & Computer Aided Inspection | 2 | 1 | - | 3 |
| 5. | DEC | Elective - I * | 3 | - | - | 3 |
| 6. | DEC | Elective - II * | 3 | - | - | 3 |
| 7. | PME-15009 | Advanced Manufacturing Laboratory-II | - | 1 | 2 | 2 |
| 8. | PME-15010 | Decision Making and Optimization Laboratory | - | - | 2 | 1 |
| 9. | ML-15004 | Intellectual Property Rights | 1 | - | - | 0 |
| 10. | LL-15002 | Liberal Learning Course | 1 | - | - | 1 |
| | | **Total** | **19** | **2** | **4** | **22** |

**Semester-III**

| Sr. No. | Course Code | Course Name | Teaching Scheme | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | PME-16001 | Dissertation Phase – I | -- | -- | -- | 16 |
| | | **Total** | **--** | **--** | **--** | **16** |

**Semester-IV**

| Sr. No. | Course Code | Course Name | Teaching Scheme | | | Credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| 1. | PME-16002 | Dissertation Phase - II | -- | -- | -- | 18 |
| | | **Total** | **--** | **--** | **--** | **18** |

*** Departmental Elective Course - I & II (Any two)**

| Sr. No. | Course Code | Course Name |
|---|---|---|
| 1 | PME(DE)-15001 | Sustainable Manufacturing |
| 2 | PME(DE)-15002 | Tribology |
| 3 | PME(DE)-15003 | Human Factors in Design & Manufacturing |
| 4 | PME(DE)-15004 | Mechatronics |
| 5 | PME(DE)-11005 | Terotechnology & Maintenance Management |
| 6 | PME(DE)-15006 | Reliability Engineering |
| 7 | PME(DE)-15007 | Precision Engineering |
| 8 | PME(DE)-15008 | Advanced Material Forming |
| 9 | PME(DE)-15009 | Computer Aided Design and Manufacturing- (Web Based E-Learning Course) |

**Open Elective Course (for other specializations)**

| Sr. No. | Course Code | Course Name |
|---|---|---|
| 1 | PE(ILE)-15004 | Project Planning and Control |
| 2 | OEC | Robot Dynamics and Analysis |

## (PE(ILE)-15004) Project Planning and Control

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

At the end of course students will be able to:

1. Comprehensive fundamental and technical knowledge of Project Planning.
2. Leadership and decision making capabilities
3. Ability to handle the project through project planning steps.
4. Ability to analyze the projects through network techniques and handle financial aspects of project.

**Syllabus Contents:**

- Function of Project Planning –Inter dependency relationship, Generation and screening of project ideas, project rating index
- Characterization of the market, demand forecasting, market planning.
- Financial Analysis; Estimation of cost of project and means of financing, estimates of sales and production, cost of production
- Working capital requirement and its financing, estimates of working results, breakeven points – projected cash flow statement,
- Project cash flows; Basic principles of measurement of cash flows, components of the cash flow streams – viewing a project from different points of view, definition of cash flows by financial institutions and planning commission
- Forms of project organization, project planning, project control, human aspects of project management, prerequisites for successful project implementation.
- Project review and administrative aspects; Initial review, performance evaluation, abandonment analysis, administrative aspects of capital budgeting, evaluating the capital budgeting system of an organization.
- Network techniques for project management, development of project network, time estimation, determination of critical path, scheduling when resources are limited, PERT and CPM models.

**References:**


1. Prasanna Chandra, “Project Planning: Analysis, Selection, Implementation and Review”, Tata Mc Graw Hill.
2. Narendra Singh, “Project Management and Control”, HPH, 2003

3. John M. Nicholas and Herman Steyn, “Project Management for Business and Technology: Principles and Practice”, Prentice Hall India
4. Clifford F. Gray & Eric W. Larson, “Project Management: The Managerial Process”, Tata Mc Graw Hill
5. Chitkara, “Construction Project Management, Planning, Scheduling and Control”, Tata McGraw-Hill, ISBN: 9780074620625
6. Merdith & Gopalan, “Project Management”, Wiley India (P) Ltd., ISBN: 8126509406

## ( MA-15005) Robot Dynamics and Analysis

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

At the end of course students will be able to:

1. Comprehensive fundamental and technical knowledge of Robotics
2. Ability to apply computing of design criteria's of robot elements
3. Ability to apply the knowledge of specifying the robot elements and selection of robots
4. Ability to analyze robots through Kinematic and Dynamic study & its programming
5. Ability to learn effective practices in uses of robots, robot economics and novel advancements in this area.

**Syllabus Contents:**

- Basic concepts, Robot anatomy, Robot configurations, Basic robot motions, Types of drives
- End effectors, Classification, Mechanical, Magnetic, Vacuum, and Adhesive. Force analysis and Gripper design
- Sensors in robot systems, non optical and optical position sensors, Velocity and Acceleration, Range, Proximity, touch, Slip, Force, Torque sensors
- Machine vision system, illumination techniques, image processing & analysis
- Translational transformations and Rotational transformations, Properties of transformation matrices-Homogeneous transformations and Manipulator
- Robot kinematics, Forward solution, Inverse solution , Control system concepts, Analysis , control of joints, Adaptive and optimal control, Trajectory Planning
- Robot Dynamics, Langragian formulation, D Alembert's principle
- Robot programming Methods - Robot programming languages - VAL Language, Computer controller and Robot communication,
- Economics of Robots, Robot Applications-Material handling, processing,-Assembly and Inspection, safety considerations. Telechiric robots.

**References:**

1. M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, “Industrial Robotics Technology”, Mc Graw Hill book Co. 1995
2. Robert J. Schilling, “Fundamentals of Robotics-Analysis and Control”, Prentice Hall India, 1990.
3. Fu K.S., Gonzalez R.C.., and Lee C.S.G., “Robotics control, sensing, vision, and intelligence”, McGraw-Hill Book Co., 1987.
4. Klafter R.D., Chmielewski T.A. and Negin M., “Robot Engineering An Intergrated approach”, Prentice Hall of India, New Delhi, 1994.
5. Deb S.R., “Robotics Technology and Flexible Automation”, Tata McGraw-Hill Publishing Co., Ltd., 1994.
6. Craig J.J., “Introduction to Robotics Mechanics and Control”, Addison-Wesley, 1999.

## ( PME-15001) Experimental Designs, Data Analysis and Quality Control

| **Teaching Scheme** | **Examination Scheme** |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

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

- Understand various distributions and apply as per the characteristics in data analysis
- Understand the concept of Hypothesis testing and Design of Experiments and carry out Regression analysis & ANOVA
- Use of statistical quality control tools and its applications

**Syllabus Contents:**

- Probability Theory and Sampling Distributions
- Basic probability theory along with examples
- Standard discrete and continuous distributions like Binomial, Poisson, Normal, Exponential etc
- Central Limit Theorem and its significance
- Some sampling distributions like $\chi 2$, t, F
- One - and Two - Sample estimation problems Introduction
- Statistical inference, classical methods of estimation
- Single sample: estimating the mean and variance.
- Two samples: estimating the difference between two means and ratio of two variances.
- One - and Two – Sample tests of hypotheses Introduction
- Testing a statistical hypothesis
- Tests on single sample and two samples concerning means and variances
- ANOVA: One – way, Two – way with/without interactions,
- Latin Squares ANOVA technique
- Principles of Design Of Experiments

- Some standard designs such as CRD, RBD, LSD
- Statistical Quality Control Introduction
- Nature of control limits
- Purpose of control charts
- Control charts for variables
- Control charts for attributes

**References:**


1. Ronald E, Walpole, Sharon L. Myers, Keying Ye, "Probability and Statistics for Engineers and Scientists" ,8th Edition, Pearson Prentice Hall, 2007
2. Douglas C. Montgomery, "Design and Analysis of Experiments",7th Edition, Wiley Student Edition, 2009
3. S. P. Gupta, "Statistical Methods" 37th Revised Edition, S. Chand & Sons, 2008
4. William W. Hines, Douglas C. Montgomery, David M. Goldsman, "Probability and Statistics for Engineering", 4th Edition, Willey Student Edition, 2006.

## ( PME-15001) Robotics and Manufacturing Automation

**Teaching Scheme**

Lectures: 2 hrs/week
Tutorials: 1 hrs/week

**Examination Scheme**

T1, T2 – 20 marks each, End-Sem Exam - 60

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Understand the basics of robotics and artificial intelligence.
2. Use fundamentals of FMS, and AGV in manufacturing situations.
3. Apply concepts of hard and soft automation in industries.

**Syllabus Contents:**

- Fundamentals of Robotics, Robot anatomy, Robot configurations
- Drives in robotics, Robot controllers
- End Effectors: types, design considerations, gripper design
- Robot kinematics – Forward & Inverse kinematics, D-H approach
- Sensors in robotics, classification, considerations and applications
- Machine vision system in robotics, Image processing
- Robot programming methods, Robot programming languages, commands and programming using VAL , Programming for welding applications
- Trajectory planning, safety in robotics, robot economics, Robot applications Artificial Intelligence and Robotics
- Automation, Elements of automated systems, advanced automation functions, levels of automation
- Types of automation, Fixed, programmable, flexible, Hard & soft automation
- Fundamentals of automated production lines, analysis of transfer lines, material handling in automated systems, Geneva mechanisms, feeders,
- Group technology, Rank order clustering, automated guided vehicle systems: types, guiding techniques, AGV system design
- FMS: components of FMS, quantitative analysis of FMS
- Inspection techniques in automation

**References:**


1. S.R. Deb, “Robotics Technology and Flexible Automation”, Tata McGraw Hill.
2. M.P.Groover, Weiss, Nagel & Odery, “Industrial Robotics Technology, Programming & Applications” , Tata McGraw Hill.
3. M.P.Groover, “Automation Production systems and Computer Integrated Manufacturing”, PHI learning Pvt. Ltd.

4. Yoram Koren, “Robotics for Engineers”, Tata McGraw Hill.
5. K. S. Fu, R. C. Gonzalez, C. S. G. Lee, “Robotics – Control, Sensing, Vision and Intelligence”, McGraw Hill Int.
6. H. J. Warneck and R.D. Sehfart “Industrial Robots” , I.F.S. Pub., U. K.
7. R. Paul, “Robots – Manipulators, Mathematics, Programming and Control”, MIT Press.
8. P.A. Janakiraman, “Robotics and Image Processing”, Tata McGraw Hill 1995.
9. J.G.Keramas “Fundamentals of Robotics”, Delmar Publishers
10. Nanua Singh, “System Approach to Computer Integrated Design and Manufacturing”, John Wiley (1996), ISBN 0-471-58517-3

## ( PME-15002) Advanced Machine Tool Design

**Teaching Scheme**

Lectures: 3 hrs/week

**Examination Scheme**

T1, T2 – 20 marks each, End-Sem Exam - 60

**Course Outcomes:**

1. The course will enable the students to understand the functioning of NC and CNC machines, FMS.
2. The students will be able to understand vibration analysis of machine tool structure.
3. An understanding of this course will help the students in application of Electrical control system.

**Syllabus Contents:**

- Classification of various machine tools and their specifications, Stepped & step less drives of various types,
- Design of the elements like columns, beds etc. for stresses and deformations using finite difference,
- Design of guides having filled, unfilled plastics.
- Design of slides and spindle supports with hydrodynamic, hydrostatic & aerostatic lubrication.
- NC machine tools and their configuration, Special design concepts of CNC machine tools, CNC machine
- Machining center, using large number of tools in ATC, Design concepts of auto changer, different types of auto changer, Building Block or modular concept in setting up aggregate machines.
- Concepts of adaptive control, DNC and Local Area Network and machines with Adaptive Control.
- Flexible Manufacturing System (FMS), and Cellular Manufacturing system (CMS)
- Ballscrew design- load, rigidity and pre-load calculation
- Drive system with Stepper motor and DC and AC Servo Motors
- Design and load estimation of servo motors, Control and feedback using positional, velocity & PID system.
- Static and dynamic rigidity, Lumped parametric method and stability and instability based on vibration analysis of machine tools-stability envelopes, Vibrational study of machine tool structures – micro-displacement and error analysis of machine tools with reference to transmission system and positional displacement (stick-slip)
- Elimination of stickslip, Non-uniform micro-displacement Reliability analysis of

machine tools.

- Electrical control system – relays, electromagnetic brakes, safety devices and reversible systems

**References:**


1. S. K. Basu and D. K. Pal, “Design of Machine Tools” , Oxford – IBH, 6th Edition, 2015
2. A. Bhattacharya and G.C. Sen, “Principles of Machine Tools”, New Central Book Agency, Calcutta
3. B. Leatham and Jones, “Computer Numerical Control Machines”
4. Yoram Koren, “Computer Control in Manufacturing” , Tata McGrew Hill.
5. Kundra, Rao and Tiwari, “Numerical Control and Computer Aided Manufacturing”, Tata McGraw Hill.
6. S.J. Martin, “NC Machine tools”, ELBS.
7. N. K. Mehta, “Machine Tool Design”, Tata McGraw Hill.

## ( PME-15003) Additive Manufacturing Processes, Machines and Applications

**Teaching Scheme**

Lectures: 3 hrs/week

**Examination Scheme**

T1, T2 – 20 marks each, End-Sem Exam - 60

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. To understand the importance of additive manufacturing process, various additive manufacturing technologies, selection of suitable material, pre processing and post processing of manufactured parts.
2. To explore different applications of additive manufacturing parts from various fields like Automobile, Aerospace, Bio-medical etc.
3. To understand basic construction of additive manufacturing machines, different systems like Energy delivery, Material delivery, Nozzle and Heating Systems
4. To understand the concept of rapid tooling and its requirement

**Syllabus Contents:**

- Introduction to Additive Manufacturing (AM), AM evolution, Distinction between AM and CNC machining, Advantages of AM
- AM process chain; Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build , removal and clean up, post processing.
- Classification of AM processes; Liquid polymer system, discrete particle system, molten material systems, solid sheet system.
- Design for AM; Motivation, Design for manufacturing and Assembly concepts and objectives, AM unique capabilities, Exploring design freedoms
- Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.
- Guidelines for process selection; Introduction, selection methods for a part, challenges of selection, example system for preliminary selection, production planning and control

- Post processing of AM parts; Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.
- AM Applications; Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models
- Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries.
- Construction of basic AM machines; Construction of CNC Machine - Axes, Linear motion

**References:**


1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.
4. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.

## ( PME-15004) Advance Manufacturing Laboratory-I

**Teaching Scheme**

Practical : 2 hrs/week

Tutorial : 1 hrs/week

**Examination Scheme**

Term Work: 100 Marks

**Course Outcomes:**

1. Students will be able to apply the knowledge of courses studied in the syllabus.
2. Students will be able to demonstrate the knowledge gained during the course in completing the assignments.
3. Able to understand part modeling and part data exchange standard.
4. Able to of fabricate 3D part using an additive manufacturing machine and carry out preprocessing, and post processing of rapid prototype part.
5. Realize the application of RP and RT technologies for product development
6. Apply the reverse engineering process for product development.
7. Able to select the design principle, suitable material, mechanism, fit and tolerance for designing a product/component.
8. To learn the fundamentals of nanotechnology and fabrication of nanofibers.
9. Able to do simple robot programming for pick and place applications, welding etc.

**Syllabus Contents: (Any Eight)**

1. Development of any solid model assembly and detail using CAD modeling packages.
2. Prototyping using 3D Printing Machine.
3. Generation of point cloud data of rapid prototype model using rotary scanner.
4. Manufacturing of nanofibers using electrospun machine.
5. Measurement of cutting forces using tool force dynamometer.
6. Robot programming and demonstration.
7. Design of Multi speed gear box with multispeed regulation.
8. Design and selection of stepper motors AC/DC servomotor with load and power consideration.
9. Design and application of ball screws with preloading.
10. Design and construction of automatic tool changer mechanism/unit.

## ( MA-15007) Experimental Design & Data Analysis Laboratory

| **Teaching Scheme** | **Examination Scheme** |
|---|---|
| | Term Work: 100 Marks |

Practical : 2 hrs/week

**Course Outcomes:**

At the end of course students will be able to

1. Use statistical analysis techniques in carrying out sampling Distribution of data, testing hypothesis.
2. Perform regression, F, t, and Chi Square tests.
3. Perform Analysis of variance & plan Design of experiments for various processes.
4. Use statistical quality control tools such as control charts.

**Syllabus Contents:**

- Sampling tests like $\chi 2$, t, F.
- One - and Two - Sample estimation problems estimating the mean and variance
- ANOVA technique
- Design of Experiments
- Mini project using above tools & Techniques

## ( ML-15001) Research Methodology

| Teaching Scheme | Examination Scheme |
|---|---|
| | Term Work: 100 Marks |

Practical : 1 hrs/week

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Understand research problem formulation.
2. Analyze research related information.
5. Follow research ethics.

**Syllabus Contents:**

- Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.
- Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations
- Effective literature studies approaches, analysis
- Plagiarism , Research ethics
- Effective technical writing, how to write report, Paper
- Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee.

**References:**


1. Stuart Melville and Wayne Goddard, “Research methodology: An Introduction for Science and Engineering Students”, Juta and Company Ltd.
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”, Juta and Company Ltd, 2004.
3. Ranjit Kumar, “Research Methodology: A Step by Step Guide for Beginners”, SAGE Publications, 2nd edition, 2005.

## ( ML-15002) Humanities

| Teaching Scheme | Examination Scheme |
|---|---|
| | T1, T2 – 20 marks each, End-Sem Exam – 60 |

Practical : 1 hrs/week

**Course Outcomes:**

At the end of the course, students will appreciate and understand, with special reference to the engineering profession:

1. The development of Civilization, Culture and Social Order over the Centuries
2. The development of Technology and its impact on the Society's Culture and vice-versa, as well as the concept of Globalization and its effects.
3. The process of Industrialization and Urbanization, their positive and negative effects, like social problems, etc.

**Syllabus Contents:**

- Introduction: The meaning of Humanities and its scope. The importance of Humanities in Society in general and for Engineers in particular.
- Social Science and Development:
- Development of Human Civilization over the centuries – Society and the place of man in society – Culture and its meaning -- Process of social and cultural change in modern India -- Development of technology, Industrialization and Urbanization, Impact of development of Science and Technology on culture and civilization -- Urban Sociology and Industrial Sociology – the meaning of Social Responsibility and Corporate Social Responsibility – Engineers' role in value formation and their effects on society.
- Introduction to Industrial Psychology:
- The inevitability of Social Change and its effects -- Social problems resulting from economic development and social change (e.g. overpopulated cities, no skilled farmers, unemployment, loss of skills due to automation, addictions and abuses, illiteracy, too much cash flow, stressful working schedules, nuclear families etc.) – Job Satisfaction -- The meaning of Motivation as a means to manage the effects of change – Various theories of Motivation and their applications at the workplace (e.g. Maslow's Hierarchy of Needs, McGregor's Theory X and Y, The Hawthorne Experiments, etc.) – The need to enrich jobs through skill and versatility enhancement – Ergonomics as a link between Engineering and Psychology

**References:**


1. Jude Paramjit S. and Sharma Satish K., "Ed: Dimensions of Social Change"
2. Raman Sharma, "Social Changes in India"

3. Singh Narendar, “Industrial Psychology”, Tata McGraw-Hill, New Delhi, 2011
4. Ram Ahuja, “Social Problems in India”

## ( PME-15005) Advanced Materials and Processing

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Identify material demanding for extreme conditions.
2. Use of SMART, nano and bio-materials.

**Syllabus Contents:**

- Materials demand for Extreme conditions of operation, material property mapping, Processing, strengthening methods,
- Treatment and properties of Superalloys, creep resistance, Ultra high strength steels
- Light metal alloys and metal matrix composites (MMC), their applications in aerospace and automobiles
- Super-plastic materials, Materials in the vicinity of nuclear fissile fuels,
- Zirconium alloys, stainless steels
- Intermetallics, Metallic glasses
- Amorphous alloys, rapid solidification, synthesis by mechanical alloying,
- SMART materials, shape memory effect
- Functionally graded materials
- Damage Tolerant Material
- Bio-Materials, Nano materials
- Surface engineering for modifying abrasion, wear, corrosion and fatigue performance,
- Preparation of the substrate, Physical Vapour Deposition, Chemical Vapour Deposition, Ion Implantation,
- Coatings for high temperature performance, Electrochemical and spark discharge and Plasma coating methods,
- Electron beam and laser surface processing, Organic and Powder coatings, Thermal barrier coating.

**References:**


1. P. Ramarao, “Advances in materials and their applications”, Wiley Eastern Ltd.
2. Smallman and Bishop, “Metals and Material Science, process, applications”
3. Polmear I.J., “Light Alloys & Metallurgy of light metals”, Arnold Press,1995.

4. Westbrook J.H & Fleischer R.L., “Intermetallic compounds VOL I & II”, John Wiley, Chichester ,1995
5. Kelly A. & Nicholson R.B. (Eds), “Strengthening methods in crystals”
6. Clyne T.W. & Withers P.J., “An introduction to metal matrix composite”, Cambridge University Press, 1993.
7. Artz & L.Schulte (Ed), “New Materials by mechanical alloying techniques”, DGM, Germany, 1989.

## ( PME-15006) Manufacturing Systems Design and Optimization

**Teaching Scheme**

Lectures: 3 hrs/week

**Examination Scheme**

T1, T2 – 20 marks each, End-Sem Exam - 60

**Course Outcomes:**

1. Student will be able to understand various manufacturing system existing in Industries.
2. The course will enable the student to apply latest techniques in manufacturing systems.
3. Students will be able to understand inventory management systems currently used in industries
4. The concepts of systems and inventory will be useful in perusing Industrial projects in the second year.

**Syllabus Contents:**

- Essentials of Manufacturing Systems
- Process for Manufacturing; material and Technological Information Flows in manufacturing systems including manufacturing cost and product cost structure
- Product planning and design, Process planning and design, Logistic planning and Design
- Manufacturing Optimization; Management Systems for Manufacturing: managerial information flow in manufacturing systems
- Aggregate Production planning
- JIT and Kanban Production Control
- Stochastic Processes in manufacturing; Discrete time Markov Chain models, DTMC with and without repair facilities for two machines systems
- Continuous time Markov chain with resume and discard policies
- Manufacturing system Analysis through TRIZ, PETRI Nets, ETPN and GSPN, Reach-ability graphs etc.

**References:**


1. Katsundo Hitomi, “Manufacturing Systems Engineering”, Viva Low-Priced Student Edition
2. Y. Narahari and N. Vishwanadhan, “Performance Modelling and Automated Manufacturing Systems” Prentice Hall India, 1994.
3. Stanley B. Gershwin, “Manufacturing Systems Engineering”, PHI latest Editon.

4. Joseph Martinich, “Production and Operations Management: An Applied Approach”, 1997, Wiley.
5. Eliyahu Goldratt, “The Goal: A Process of Ongoing Improvement”, 2nd Revised Edition, Jeff Cox, 1992.

## ( PME-15007) Advanced Manufacturing Technology

| **Teaching Scheme** | **Examination Scheme** |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. The student will be able to understand the latest developments in the field of manufacturing technology.
2. The concepts of Nano-processing can thus be used in research work
3. An understanding of Abrasive jet, water jet, ultrasonic machining will be applied in the industry which will result in precision working.

**Syllabus Contents:**

- Overview of MEMS & Microsystems: Evolution of microsensors,
- MEMS & microfabrication – typical MEMS and Microsystems and miniaturization – applications of microsystems.
- Working Principle of Microsystems: Microsensors: pressure, thermal, optical, chemical, biomedical-microactuation, thermal, shape-memory alloys, piezoelectric, electrostatic
- MEMS with microactuators
- Materials for MEMS-MEMS fabrication: Photolithography, ion implantation, Physical Vapour Deposition, oxidation, chemical vapor deposition and plasma spraying
- Overview of micromanufacturing: bulk and surface micromachining,
- LIGA process. $CO_2$ laser and HPDE (High powered diode electrode) lasers used for high speed bending of plates.
- Microsystem Design, Packaging Consideration and Applications;
- Rapid Prototyping; FDM, SLA etc.
- Microrobotics-microscale vacuum pumps, micro heat pipes, inertial sensors etc
- Molecular dynamic simulation and Laser Induced Plasma (LIP) processes.
- Nano Technology: nanoprocessing systems, mechanism of material processing
- Nanomeasuring systems, scanning tunneling microscope used in nano positioning

- Machining by Abrasive Jet, Water Jet, Abrasive Flow, Ultrasonic, Thermal assistance, Form Machining and low stress grinding.
- Rotary ECDM vibro rotary ECDM, Dry and Near dry EDM process with vibration.
- Thermal energy methods of material processing (machining/welding/heat treatment) by Electro-discharge, Laser and Electron beam, Plasma arc and Ion beam.
- High Energy Rate Forming and Electroforming.

**References:**


1. Tai ran Hsu, "MEMS & Microsystem: Design & Manufacture" , Tata McGraw Hill Publisher, 2002.
2. "The MEMS handbook", CRC Press, 2001
3. Julian W. Gardner & Vijay K. Varadan, "Microsensors, MEMS and smart Devices", John Wiley & Sons, 2001.
4. Nario Taniguchi, "Nanotechnology", Oxford University Press, 1996.

## ( PME-15008) Metrology & Computer Aided Inspection

| Teaching Scheme | Examination Scheme |
|---|---|
| | T1, T2 – 20 marks each, End-Sem Exam - 60 |

Lectures: 2 hrs/week
Tutorial : 1 hrs/week

**Course Outcomes:**

1. Students will be able to handle high precision measurement requirements of industry.
2. Knowledge of different instruments used for high precision will be applied by the student in the industry and research work.

**Syllabus Contents:**

- Metrological concepts - Abbe's principle - need for high precision measurements - problems associated with high precision measurements.
- Standards for length measurement - Shop floor standards and their calibration
- Light interference - Method of coincidence - Slip gauge calibration - Measurement errors.
- Various tolerances and their specifications, gauging principles, selective assembly, comparators.
- Angular measurements - principles and instruments.
- Gear and Thread measurements.
- Surface and form metrology - flatness, roughness, waviness, roundness, cylindricity, etc.
- Computer Aided Metrology - Principles and interfacing, software metrology.
- Laser metrology - Applications of Lasers in precision measurements.
- Laser interferometer, speckle measurements, laser scanners.
- Coordinate Measuring Machine - Types of CMM - Probes used - Applications - Non contact CMM using Electro optical sensors for dimensional metrology - Non contact sensors for surface finish measurements.
- Image processing and its application in Metrology.

- Large scale Metrology, Laser Trackers, Stereo vision, Micro and Nano Metrology.

**References:**


1. K.J.Hume, “Engineering Metrology”, Kalyani Pusblisher Latest Editon, New Delhi.
2. R. K. Jain, “Engineering Metrology”, Khanna Publishers, New Delhi
3. I.C. Gupta, “Engineering Metrology”, Dhanapat Rai New Delhi
4. Robert G. Seippel , “Opto Electronics for Technology and Engineering”, Prentice Hall New Jersey, 1989.
5. Thomas G.G, “Engineering Metrology”, Butter worth publications-1974
6. Anil K. Jain, “Fundamentals of Digital image processing”, Prentice hall of India Pvt. Ltd. 2004
7. Dale H. Besterfield, “Total Quality Management”, Pearson Education Asia, 2002.
8. Manuals of Co-ordinate measuring machines and systems

## ( PME-15009) Advance Manufacturing Laboratory-II

**Teaching Scheme**

Practical : 2 hrs/week

Tutorial : 1 hrs/week

**Examination Scheme**

Term Work: 100 Marks

**Course Outcomes:**

1. Students will be able to apply the knowledge of courses studied in the syllabus.
2. Students will be able to demonstrate the knowledge gained during the course in completing the assignments.
3. Able to apply the working principles and processing characteristics of nontraditional machining like EDM, ECDM to the production of precision components.
4. Able to determine the quality and surface integrity of products manufactured by advance manufacturing process.
5. Able to apply advance manufacturing process with socio-economic considerations.
6. Able to use different laser technologies in manufacturing and measurement.
7. Able to build, validate and verify simulation model for forming process simulation.
8. Able to evaluate the part and estimate machine tool accuracies.

**Syllabus Contents: (Any Eight)**

1. To investigate the effect of material removal rate (MRR), Tool Wear and Surface roughness on workpiece and tool Electrical Discharge Machining (EDM) and rapid EDM drilling machine.
2. Microdrilling Using Electrochemical Discharge Machining (ECDM).
3. Measurements of circularity and cylindricity of parts using Coordinate Measuring Machine (CMM).
4. Inspection process using Vision Measuring System.
5. Use of Laser Interferometer and to find error in linear positioning for NC, CNC machines.
6. Friction and wear behavior of material using different Tribometers.
7. Analysis of wear particles using Direct Reading Ferropgraph and Dual Slide Ferrogram Maker.
8. Use of Dynamic Mechanical Analyser (DMA) to find mechanical properties of Polymeric material.
9. Metal forming process simulation using software.

10. Study of Fractography by using Field Emission Scanning Electron Microscope.

## ( PME-15010) Decision Making and Optimization Laboratory

| Teaching Scheme | Examination Scheme |
|---|---|
| Practical: 2 hrs/week | Term Work: 100 Marks |

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Perform decision making using AHP, TOPSIS, SAW,WPM
2. Optimise the parameters using Genetic Algorithm (GA)
3. Model & Simulate the system
4. Carry out simple Layout simulation and assembly line simulation

**Syllabus Contents:**

- Layout simulation and Assembly line simulation using simple situations
- Generating and evaluating what –if scenarios for finalizing layout Analytical tools: Simple Additive Weighting (SAW), Weighted Product Method (WPM)
- Analytical Hierarchy Process (AHP) for MCDM
- TOPSIS & Modified TOPSIS method for MCDM
- Optimization using Genetic Algorithm (GA)

## (ML-15004) Intellectual Property Rights

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures:1 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
2. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
3. Understand how IP is an important element of the institutional fabric of an efficiently organized society.
4. Understand that Intellectual property is about preserving the differences between competitors.
5. Understand that Intellectual property right (IPR) is an attempt to safeguard the rights of original contributor of ideas, concept, and creativity of individuals.
6. Understand that how at present, IPR are regarded as a source of national wealth and mark of an economic leadership in the context of global market scenario.
7. Understand the national IP system.
8. Got familiarized with the origins and the development of the international framework of IP
9. Created internal vigilance and enlightenment among students to generate new ideas.
10. Makes students understand that things are dynamic and more complex than they appear which reinforces the motivation of the students to learn
11. Students find answers to many of the whys and why not's.
12. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.
13. As such the importance to emphasis the need of awareness and knowledge about IPR in engineering students, who are tomorrow's technocrats and creator of new technology.

**Syllabus Contents:**

- Introduction: Nature of patents, designs, trademarks and copyright.

- Process of patenting and development: technological research, innovation, patenting, development.
- International Scenario: International cooperation on intellectual property. Procedure for grants of patents, patenting under PCT.
- Patent Rights: Scope of patent rights. Licensing and transfer of technology.
- Patent information and databases. Geographical Indications.
- New Developments in IPR: Administration of patent system.
- IPR of biological systems, computer software etc.
- Traditional knowledge, case studies, IPR and IITs.
- Registered and unregistered trademarks, design, concept, idea patenting.

**References:**


1. Halbert, “Resisting Intellectual Property”, Taylor and Francis Ltd ,2007.
2. Mayall, “Industrial Design”, Mc Graw Hill.
3. Niebel, “Product Design”, Mc Graw Hill.
4. Asimov, “Introduction to Design”, Prentice Hall.
5. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”
6. T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand Co.

## (LL-15002) Liberal Learning Course

**Teaching Scheme**

Lectures:1 hrs/week

**Examination Scheme**

T1, T2 – 20 marks each, End-Sem Exam - 60

**Course Outcomes:**

At the end of the course, students will demonstrate the ability to:

1. Learn new topics from various disciplines without any structured teaching or tutoring
2. Understand qualitative attributes of a good learner
3. Understand quantitative measurements of learning approaches and learning styles
4. Understand various sources and avenues to harvest/gather information
5. Assess yourself at various stages of learning

**Course Features:**

- 10 Areas, Sub areas in each
- Voluntary selection
- Areas (Sub areas):
    1. Agriculture (Landscaping, Farming, etc.)
    2. Business (Management, Entrepreneurship, etc.)
    3. Defense (Study about functioning of Armed Forces)
    4. Education (Education system, Policies, Importance, etc.)
    5. Fine Arts (Painting, Sculpting, Sketching, etc.)
    6. Linguistics
    7. Medicine and Health (Diseases, Remedies, Nutrition, Dietetics, etc.)
    8. Performing Arts (Music, Dance, Instruments, Drama, etc.)
    9. Philosophy
    10. Social Sciences (History, Political Sc., Archeology, Geography, Civics, Economics, etc.)

**Evaluation:**

- T1: A brief format about your reason for selecting the area, sub area, topic and a list of 5 questions (20 marks)
- T2: Identify and meet an expert (in or outside college) in your choice of topic and give a write up about their ideas regarding your topic (video /audio recording of your conversation permitted (20 marks)
- ESE: Presentation in the form of PPT, demonstration, performance, charts, etc. in front of

everyone involved in your sub area and one external expert (60 marks)

**Resources:**

- Expert (s), Books, Texts, Newspaper, Magazines, Research Papers, Journal, Discussion with peers or faculty, Internet, etc.

## (PME(DE)-15002) Tribology

| **Teaching Scheme** | **Examination Scheme** |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. Students will be able to demonstrate the behavior and characteristics of various lubricants in static and dynamic conditions.
2. Students will be able to select a lubricant for a particular process depending on the type of material and working conditions.

**Syllabus Contents:**

- System analysis and its application in tribo-environments
- Contract theory of surface, ergodicity and stationarity of a surface, aborts bearing area curve and distribution of asperities heights.
- Apparent evaluation of contact stiffness of a joint.
- Adhesive and abrasive theories of friction with modification, method of measuring static and dynamic coefficient of friction
- Definition of wear and its various forms. Parameters affecting friction and wear, adhesive, abrasive, erosive wear etc. and analytical as well as experimental methods of determination
- Typical characteristics of the lubricant to reduce friction as well as vibration. Lubrication test kits.
- Dry friction, boundary friction, semi-liquid and liquid and liquid friction under lubrications.
- Case studies : showing monitoring of wear in reciprocating compressor using Ferrography and Quantitative Debris Monitoring(QDM), such As particle analyzer etc. Vibration signature analysis. Noise to detect failures.
- Tribological failure analysis SOAP: Spectroscopic oil analysis program. Uses of lubricant in radial journal bearing, thrust bearing. Hydrostatic, Hydrodynamic and Ealstohydrodynamic etc.
- Characteristics of lubricant for different type of uses and their properties under

different environmental condition.

- Use of solid lubricant in specific cases of extrusion and metal cutting. Method of testing and characterization.

**References:**


1. S.K.Basu, B.B. Ahuja and S.N. Sengupta, “Fundamentals of Tribology”,6th Edition PHI, New Delhi.
2. Kragelsky, “Friction, lubrication, wear- Vol I,II and III”
3. B.C. Mujumdar, “Introduction to Tribology of bearings”, S Chand Publications, Delhi.
4. H.Czichos and Elsevies, “Tribology – A System Approach”, Latest Editon.
5. E. Rabinowics, Friction and Wear of Materials, Wiley N.Y.
6. Hailing J., "Principles of Tribology", MeMillan Press Ltd.
7. Fuller D.' D. "Theory and Practice of Lubrication for Engineers". John Wiley and Sons.
8. Neale M. J. "Tribology hand Book", Butterworths.

## (PME(DE)-15003) Human Factors in Design and Manufacturing

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. Students will understand the importance of ergonomics in day to day life.
2. The knowledge of human factors will lead to different applications in Industry as well as dissertation.
3. Student will be able to assess the human efforts to perform a particular task. The assessment and analysis of the task will help in reducing human efforts.

**Syllabus Contents:**

- Introduction: Human Factors and Systems, Information Input and Processing, Visual Displays of Dynamic Information
- Human Output and Control: Physical Work and Manual Materials Handling, Motor Skills, Human Control of Systems
- Controls and Data Entry Devices, Hand Tools and Devices Work Place Design.
- Applied Anthropometry, Work-Space Design, and Seating, Arrangement of Components within a Physical Space
- Interpersonal Aspects of Workplace Design Environmental Conditions: Illumination, Climate, Noise, and Motion human Factors Applications.
- Human Factors in Design and Manufacturing, Dynamic consideration in design of product using vibration stability in biomechanisms.
- Safety in manufacturing. Considerations of human stress, Allowable limit of stress, stress adjustment.
- Evaluation human learning phenomenon, Progress Elasticity and the factors influencing the same.
- Determination of Training period for discrete and repetitive tasks. Machine Learning index.
- Estimation of human error and human reliability, combining various forms of human error by random number simulation
- Human Error, Accidents and safety, Human Factors and the Automobile, Human Factors in Systems Design, Manpower planning, job allocation.

**References:**

1. Mark S.Sanders, Ernest. J. Mcormick, “Human Factors in Engineering and Design”, 7th Edition, McGrath Hill, NY
2. C.T.Morgan, J.S.Cook, A. Chapnis and M.W.Land, “Human Engineering- Guide to Equipment design”, McGraw Hill, N.Y, 1963.

## (PME(DE)-15004) Mechatronics

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. At the end of the course the student will be able to correlate manufacturing and Electronics interfaces.
2. Student will be able to address issues related to integrated design issues related to Mechatronics.
3. Student will apply the knowledge of Mechatronics related to data acquisition, measurement and control systems..

**Syllabus Contents:**

- Introduction to Mechatronics, Evolution of Mechatronics, Application areas of Mechatronics Modeling and Design, Mechatronics Design Concept, Mechatronics Systems
- Introduction to Measurement Systems, Control Systems, Micro-processor based controllers, Response of systems, Signal conditioning,
- The Operational Amplifier, Protection, Filtering, Elements of a Data Acquisition and Control System, Overview of the Input/Output Process, Examples, Overframing, Quantizing Theory
- Hardware for Analog to Digital Conversion, Analog to Digital (A/D) Conversion, Digital to Analog (D/A) Conversion, Data Acquisition Case Studies, Data Acquisition and Control Case Studies.
- Interfacing, Input/Output Addressing, Interface Requirements, Peripheral Interface Adapters, Serial Communications Interface, Examples of Interfacing
- Basic Structure of PLC, PLC Hardware, Ladder Diagrams, Input/Output Processing, Programming, Mnemonics, Timers, Internal Relays and Counters, Shift Registers, Master and Jump Controls, Data Handling, Analog Input/Output, Selection of a PLC.
- Introduction to Sensors and Transducers, Performance Terminology, sensors used in measurement of displacement, position and proximity, velocity and motion, force, fluid pressure, liquid flow, liquid level, temperature, Light, stress and strain,

vibration and acceleration, pressure and flow, semiconductor sensors and micro-electromechanical devices, Selection of sensors,

- Inputting data by switches. Other types of sensors, Tactile sensing, Digital Transducers, Advantages of Digital Transducers.
- Introduction to actuation system, Pneumatic and Hydraulic Actuation Systems, Mechanical Actuation Systems, Electromagnetic Principles, Electrical Actuation Systems, Selecting a motor, Piezoelectric actuators.
- Integrated design issues in Mechatronics, Mechatronics Key Elements, Traditional and Mechatronics designs.
- The Mechatronics Design Process, Possible Mechatronics Design Solutions, Advanced approaches in Mechatronics, Control architectures, Advanced Applications in Mechatronics: Sensors for Condition Monitoring, Mechatronic Control in Automated Manufacturing, AI in Mechatronics,
- Fuzzy Logic Applications in Mechatronics, Micro sensors in Mechatronics, Case studies in Mechatronics.

**References:**


1. Michael B. Histand and David G. Alciatore “Introduction to Mechatronics and Measurement Systems”, McGraw-Hill International Edition.
2. W. Bolten “Mechatronics Electronic Control Systems in Mechanical and Electrical Engineering”, 3rd Edition, Pearson Education (Low Price Edition).
3. Clarence W. De Silva “Mechatronics : An Integrated Approach”, CRC Press.
4. Lawrence J. Kamm, “Understanding Electro-Mechanical Engineering: An Introduction to Mechatronics”, Prentice – Hall of India Private Limited, New Delhi.
5. HMT Limited, “Mechatronics”, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Devdas Shetty and Richard A. Kolk, “Mechatronics System Design”, PWS Publishing Company (An International Thomson Publishing Company).
7. Nitaigour Premchand Mahalik, “Mechatronics: Principles, Concepts and Applications”, Tata McGraw Hill Publishing Company Limited, New Delhi.

## ( (PME(DE)-11005) Terotechnology & Maintenance Management

**Teaching Scheme**

Lectures: 3 hrs/week

**Examination Scheme**

T1, T2 – 20 marks each, End-Sem Exam - 60

**Course Outcomes:**

1. Student will be able to demonstrate the skills related to life cycle costing and condition based monitoring.
2. Student will understand various aspects of maintenance in practical situations.
3. Student will be able to handle various software's and equipments related to Terotechnology.

**Syllabus Contents:**

- Maintenance Management Practice –Various types of maintenance, breakdown, preventive, periodic or predictive, condition based maintenance as predictive preventive maintenance.
- Online or off-line CBM, concept of health as well as usage monitoring.
- Quantitative decision making for selection of maintenance system & management classification of material, MICLASS, CUSDD, Software for Classification and Coding.
- Spare Parts Management- Simulation and Software needed for spare parts management and inventory planning.
- Periodic Preventive Management – Scheduled maintenance and period for P.M.
- Life cycle cost taking into consideration maintenance, reliability, hazard function etc. Life cycle costing: Rigorous models, mathematical formulation etc.
- Condition based maintenance, using Vibration Signature, SOAP, ferrography, hot ferrography, Infra Red Camera, fluorescent dye, Quantum Debris Analysis using Particle Analysers and other diagnostic techniques.
- Reliability Centered Maintenance. Total Productive Maintenance: Organisation, merits and demerits.
- Terotechnology and its influence on plant engineering and maintenance, specific application areas, Overall effectiveness of equipment (OEE) and its measurement
- RAM analysis: Reliability, Availability, Inherent & Operational and Maintainability.

**References:**


1. B Bhadury and S.K. Basu, "Terotechnology: Reliability Engineering and Maintenance Management", Asian Books, New Delhi 2002.
2. A. K. Gupta, "Terotechnology & Reliability Engineering", McMillan Co.
3. A. K. S. Jardine, "Maintenance, Replacement & Reliability", HMSO, London.

4. C. Singh and C.S. Dhillon, “Engineering Relaibility-New Techniques and Applications”,John Wiley and Sons, Tata McGraw Hill Publishing Company Limited, New Delhi.

## (PME(DE)-15006) Reliability Engineering

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. Student will be able to understand the importance and application of reliability.
2. Student will be able to use the concepts of reliability in designing and maintenance of products.
3. Student will be able to simulate techno economic life which is very important for industry application.

**Syllabus Contents:**

- Basic Probability, concept and various distributions. Concept of Reliability and analysis of various configurations of assemblies and sub-assemblies. Series, Parallel and other grouping.
- System reliability. Set theory, optimal Cut Set and Tie Set, ‘star-delta’ method, matrix method etc.
- System reliability determination through ‘Event Tree’ analysis and Fault tree analysis.
- Usage monitoring of plant and evaluation of reliability through failure data analysis.
- Concept of loading roughness, probability in design including evaluation of safety margin.
- Reliability of Engineering Design; Mean, Median & K statistics for Reliability evaluation (non parametric, Short Sample).
- Monte-Carlo simulation and Techno economic life. Optimal allocation of component reliability to achieve maximum system reliability- various techniques and methods such as Minimum Effort method, Proportional, Conditional, AGREE, ARINC, Fair & Kim’s Algorithm, etc.
- Reliability, Availability and Maintainability of equipment. A number of case studies done in Indian perspectives using Short Sample, nonparametric reliability.
- Failure Modes and Effects Analysis (FMEA), Failure Modes, Effects and Criticality Analysis (FMECA). R.P.N., Graph theory etc.
- Diagnostic maintenance through ferrography, Vibration Signature, SOAP and other

programme.

**References:**


1. L.S.Srinath, “Concepts in Reliability Engineering” Affiliated East West Press.
2. K.C.Kapoor and L.R.Lubersome, “Reliability in Engineering Design”,Willey
3. C. Singh and C.S.Dhillon ,“Engineering Relaibility New Techniques and Applications”John Wiley and Sons.
4. F.J.Henley Hirmotus, “Designing for Reliability and Safety Control”.
5. B Bhadury and S.K. Basu, “Terotechnology: Reliability Engineering and Maintenance Management”, Asian Books, New Delhi 2002.

## (PME(DE)-15007) Precision Engineering

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. Student will be able to identify errors due to various measurements.
2. Precise measurement techniques will be applied in industry as well as projects to be undertaken in the second year.

**Syllabus Contents:**

- Errors Due to Numerical Interpolation, Errors Due to Displacement Measurement System, Definition of Accuracy of a Numerical Control System, Periodic Errors, Errors Due to velocity lag, Transient Response.
- Error Analysis in Dimensional Chain for single as well as multiple variables.
- Static Stiffness and Its Influence on Machining Accuracy, Classification of Errors; Errors
- Errors due to variation of total compliance of the process , Types of Errors caused by cutting force deformation in turning, boring and milling, case studies and calculation for overall errors by simulation.
- Condition monitoring in machining processes using acoustic emission.

**References:**

1. R.L. Murthy, Precision Engineering in Manufacturing, New Age International Pvt Ltd, New Delhi, Reprint 2005.

## (PME(DE)-15008) Advanced Material Forming

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. After completing the course the students will be able to understand different bulk forming processes, applications and limitations.
2. Student will be able to use different sheet metal forming process in industry based upon the conceptual learning of formability.

**Syllabus Contents:**

- Theory of plasticity – yield criteria-work of plastic deformation-Equilibrium in Cartesian, cylindrical and spherical coordinates, different method of analysis, Energy-slab method of analysis, upper bound energy method, lower bound solution, Overview of FEM applications in Metal forming analysis-specifically in drawing & extrusion of metals.
- Effect of friction in forming operation, Experimental techniques of evaluation of friction in metal forming, deep drawing.
- Theory and Practice of Bulk Forming Processes: Analysis of plastic deformation in Forging, Rolling, Extrusion and drawing processes flow stress and effect of temperature.
- Selection-Die materials-Forming process equipment design.
- Sheet Metal Forming-Formability studies-conventional processes, HVF, HERF techniques-super plastic forming techniques-Hydro forming-Stretch forming-
- Laser beam forming-principles and process parameters-Advantages, limitations and applications of different forming processes.
- Special Forming Processes: Orbital forging-Isothermal-Hot and cold isostatic pressing-High speed extrusion, Water hammer forming
- Overview of P/M technique, Advantages, applications-powder performs forging-powder rolling-Tooling, process parameters and applications.

**References:**


1. Altan T., “Metal Forming-Fundamentals and applications”, American Society of Metals, Metals park 1983.
2. Hosford WF and Caddell R.M, “Metals Forming : Mechanics and Metallurgy”, Prentice hall, Englewood Cliffs, 1993
3. ASM handbook, “Forming and Forging”, 9th Edition, vol-14, 1998.

## (PME(DE)-15009) Computer Aided Design and Manufacturing (Web Based E Learning Course)

| Teaching Scheme | Examination Scheme |
|---|---|
| Lectures: 3 hrs/week | T1, T2 – 20 marks each, End-Sem Exam - 60 |

**Course Outcomes:**

1. After completing the course the students will be able to use transformations and Projections.
2. After completing the course the students will be able to perform 1D, 2D and 3D Finite Element Problems.

**Syllabus Contents:**

- An Introduction to CAD
- Input Output Devices, Raster Graphics
- Raster Graphics - I
- Raster Graphics - II
- Polygon Filling
- Windowing and Clipping
- Clipping of Polygons
- 2D Transformations
- 3D Transformations and Projection
- Perspective Projections
- Projections and Hidden Surface Removal
- Hidden Surface Removal
- Finite Element Method : An Introduction
- Galerkin's Approach
- Galerkin's Method : 1D Finite Element Method
- 1D Finite Element Problems
- FE Problems : Solving for Q
- 1D - FE Problems : Galerkin's Approach
- Penalty Approach and Multi Point Boundary
- Quadratic Shape Functions
- 2D - FE Problems
- 3D - FE Problems

- 3D - Tetrahedral and 2D - Quadrilateral Element
- Mesh Preparation
- Modeling of Curves
- Modeling of B-spline Curves
- Surface Modeling
- Display of Curves and Surfaces
- Solid Modeling
- Solid Modeling Using Octrees
- Computer Aided Design
- Computer Aided Manufacturing
- What is CAD/CAM
- Parametric Cubic Curve
- Parametric Bezier Curve
- Solid Modeling
- Geometric & Product Data Exchange
- Reverse Engineering

**References:**

1. Web based resource like NPTEL and Online open course ware based upon above topics.