# Department: Mechanical Engineering, Tezpur University
# Programme: M. Tech. in Manufacturing Technology and Automation
# Learning Outcomes based Curriculum

## Preamble

In a learning outcome-based teaching pedagogy, the demonstrated achievement of outcomes in terms of knowledge, understanding, skills, attitudes, and the academic standard of the graduates is a key concern. Designing the programme outcomes (POs) for a particular post graduate (PG) programme, based on what a postgraduate in Manufacturing Technology and Automation is expected to know, understand and able to do at the end of the study programme is undoubtedly an important aspect. The expected POs are also crucial reference points in the sense that these assist in formulating graduate attributes, qualification descriptors, programme learning outcomes and course outcomes etc. Proper formulation of the above also helps in curriculum planning and development, and also in the design, delivery and review of academic programmes. The two years M. Tech. programme in Manufacturing Technology and Automation has been designed taking into consideration the above factors so that all the attributes of a learning outcome based curriculum is met. Additionally, inputs from statutory bodies such as AICTE, NAAC and NBA, along with inputs from stake holders are also taken in consideration before formulating the curriculum.

## 1. Introduction

The M. Tech. programme in Manufacturing Technology and Automation is offered with the following Programme Educational Objectives (PEOs):

**1)** Impart knowledge on advanced topics of Manufacturing Technology and Automation.
**2)** Practice engineering knowledge, critical thinking and real life problem solving.
**3)** Pursue research and develop creative and innovative ideas in Manufacturing Technology and Automation and other interdisciplinary areas.
**4)** Prepare students for higher learning and successful career in academia, industry and the government sector.
**5)** Inculcate in students the sense of responsibility, professionalism, ethics and leadership.

## 2. Qualification descriptors for the graduates

**a) Knowledge & Understanding** (maximum 3)

- Demonstrate a dedicated understanding in field of specialization in Manufacturing Technology and Automation, its different learning areas and applications, and its linkages with related disciplinary areas/subjects.
- Demonstrate procedural knowledge that creates different types of professionals related to the specialized domain of Manufacturing Technology and Automation, including research and development, teaching and academics and also the industrial sector.
- Demonstrate comprehensive knowledge about the domain of specialization, including research, relating to essential learning areas pertaining to Manufacturing Technology and Automation. Also develop techniques and skills required for identifying problems and issues relating to the specialized field of study.

**b) Skills & Techniques** (Maximum 3)

- Demonstrate skills in areas related to specialization in Manufacturing Technology and Automation and be up to date on the current developments in the field of specialization.
- Demonstrate skills related to the specialization in Manufacturing Technology and Automation which are transferable and relevant/required for jobs in industrial sectors and employment opportunities.
- Apply one's knowledge on the specialization in Manufacturing Technology and Automation and transferable skills to new/unfamiliar contexts, to identify and analyse problems and issues and solve complex problems with well-defined solutions.

**c) Competence** (Maximum 3)

- Meet one's own learning needs, drawing on a range of current research and development work and professional materials.
- Communicate the results of studies undertaken in an academic field accurately in a range of different contexts using the main concepts, constructs and techniques of the subject(s)
- Demonstrate competence in identifying information needs, collection of relevant quantitative/qualitative data, analysis and interpretation of data using methodologies as appropriate to the subject(s) for formulating evidence-based solutions and arguments.

## 3. Graduates Attributes

- Scholarship of knowledge
- Critical thinking
- Problem solving
- Research skill
- Modern tool usage
- Collaborative and multidisciplinary work
- Project management
- Communication
- Life-long learning
- Ethical practices and social responsibility
- Independent and reflective learning

## 4. Program Outcomes:

The students from this program will attain:

**1)** An ability to independently carry out research /investigation and development work to solve practical problems.

**2)** An ability to write and present a substantial technical report/document.

**3)** An ability to demonstrate a degree of mastery and in-depth knowledge in the following specialized areas:

**a)** Manufacturing Technology

**b)** Application of Automation in Manufacturing Technology

**c)** Materials Engineering for Manufacturing

**d)** Design, analysis and optimization of Manufacturing systems

## 5. PROGRAMME STRUCTURE:

Detail Structure of M. Tech. curriculum (Specialization: Manufacturing Technology and Automation) is given below:

**Total Credits: 82**

| | Course Category | Course Details | | | | | | | | Category -wise credits |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **SN** | **Code** | **Title** | **L** | **T** | **P** | **CH** | **CR** | |
| **I** | **Core courses** | 1 | MEMT583 | Physics of Manufacturing Processes | 3 | 1 | 0 | 4 | 4 | 61 |
| | | 2 | MEMT514 | Computer Aided Design and Manufacturing | 3 | 1 | 0 | 4 | 4 | |
| | | 3 | MEMT584 | Automation in Manufacturing | 3 | 0 | 1 | 5 | 4 | |
| | | 4 | MEMT530 | Numerical methods | 3 | 0 | 1 | 5 | 4 | |
| | | 5 | MEMT515 | Experimental Methods in Design and Manufacturing | 1 | 0 | 2 | 5 | 3 | |
| | | 6 | MEMT594 | Term Paper | 0 | 0 | 0 | 0 | 2 | |
| | | 7 | MEMT615 | MTech Thesis part I | | | | | 20 | |
| | | 8 | MEMT616 | MTech Thesis part II | | | | | 20 | |
| **II** | **Elective courses** | 1 | xx-xxx | Elective I | | | | | 3* | 21 |
| | | 2 | xx-xxx | Elective II | | | | | 3* | |
| | | 3 | xx-xxx | Elective III | | | | | 3* | |
| | | 4 | xx-xxx | Elective IV | | | | | 3* | |
| | | 5 | xx-xxx | Elective V | | | | | 3* | |
| | | 6 | xx-xxx | Open Elective I | | | | | 3* | |
| | | 7 | xx-xxx | Open Elective II | | | | | 3* | |
| **Total** | | **15** | **Minimum credit to be completed for award of the degree** | | | | | | | **82** |

## 6. SEMESTER-WISE SCHEDULE:

### Specialization: Manufacturing Technology and Automation

| Semester | Course Details | | | | | | | | Semester-wise credits |
|---|---|---|---|---|---|---|---|---|---|
| | **SN** | **Code** | **Title** | **L** | **T** | **P** | **CH** | **CR** | |
| **I** | 1 | MEMT583 | Physics of Manufacturing Processes | 3 | 1 | 0 | 4 | 4 | 21 |
| | 2 | MEMT514 | Computer Aided Design and Manufacturing | 3 | 1 | 0 | 4 | 4 | |
| | 3 | MEMT530 | Numerical methods | 3 | 0 | 1 | 5 | 4 | |
| | 4 | xx-xxx | Elective I | | | | | 3* | |
| | 5 | xx-xxx | Elective II | | | | | 3* | |
| | 6 | xx-xxx | Open Elective I | | | | | 3* | |
| **II** | 1 | MEMT584 | Automation in Manufacturing | 3 | 0 | 1 | 5 | 4 | 21 |
| | 2 | MEMT515 | Experimental Methods in Design and Manufacturing | 1 | 0 | 2 | 5 | 3 | |
| | 3 | MEMT594 | Term Paper | 0 | 0 | 0 | 0 | 2 | |
| | 4 | xx-xxx | Elective III | | | | | 3* | |
| | 5 | xx-xxx | Elective IV | | | | | 3* | |
| | 6 | xx-xxx | Elective V | | | | | 3* | |
| | 7 | xx-xxx | Open Elective II | | | | | 3* | |
| **III** | 1 | MEMT615 | MTech Thesis part I | | | | | 20 | 20 |
| **IV** | 1 | MEMT616 | MTech Thesis part II | | | | | 20 | 20 |
| **Total** | **15** | **Minimum credit to be completed for award of the degree** | | | | | | | **82** |

## 7. EVALUATION PLAN:

The evaluation plan adopted is a continuous comprehensive evaluation system designed by the university as follows.

| | | |
|---|---|---|
| 1. | Sessional Test-I | 25 |
| 2. | Mid-sem examination | 40 |
| 3. | Sessional Test-II | 25 |
| 4. | End-sem Examination | 60 |

The evaluation plan adopted is a continuous comprehensive evaluation system designed by the university. As a part of the evaluation plan, question papers are set with levels based on Bloom's taxonomy, with each question linked to the respective course outcomes. Subsequently, the attainment of course outcomes is assessed based on the students' performance in the test (marks attained by the students against questions linked to a particular course outcome).

## 8. DETAILED SYLLABUS:

The detailed syllabus along with their credit structure is given in Annexure II.

# Annexure II

## M. Tech. Syllabus (Specialization: Manufacturing Technology and Automation)

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## Core Courses

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**MEMT583: Physics of Manufacturing Processes** **L-T-P-CH-CR: 3-1-0-4-4**

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**Fundamentals of Manufacturing Physics:** Stress and strain behavior of materials; plastic and tangent modulus; work hardening; plastic instability in tensile test; empirical stress-strain equations; strain-rate and eigen values; octahedral stresses; analysis of strain and strain rates; stress equilibrium and objective stress rates.

**Machining processes:** Physics of orthogonal cutting and oblique cutting; Analytical, mechanistic modelling for cutting forces in turning, milling (straight and helical cutters), and drilling processes; Analytical and experimental methods for identification of cutting force coefficients, Heat generation in machining, Measurement and modeling of cutting temperature.

**Welding processes:** Basics of welding; heat flow - temperature distribution-cooling rates - influence of heat input, joint geometry, plate thickness, preheat; design requirements, temperature distribution , cooling rates allowable stress values, solidification in welding, weld microstructure, workmanship, inspection and standards.

**Casting processes:** Introduction to casting processes; solidification, nucleation and grain growth, short and long freezing range alloys, Rate of solidification, macrostructure and microstructure; solidification contraction, gating and risering design calculations, Micro Casting: Principle of casting processes like vacuum, Semi-solid state, Applications.

**Forming processes**: Effect of processing parameters on forming; deformation processes: Uni-axial tension, yielding, flow rule, work hardening hypothesis, mechanism of plastic deformation, isotropic and anisotropic yield functions, Slip line field theory, Upper bounds and lower bounds, Slab method of analysis.

**Text and Reference Books:**


1. M. P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, 7th Edition, Wiley, 2020.
2. A. Bhattacharya, Metal Cutting: Theory and Practice, New Central Book Agency.
3. International Institute of Welding, The Physics of Welding (Materials Science & Technology Monographs), Woodhead Publishing.
4. A. Ghosh and A. K. Mallik, Manufacturing Science, 2nd Edition, East-West Press Pvt. Ltd., 2010.
5. B. Avitzur, Metal Forming Processes and Analysis, McGraw-Hill Inc., 1983.
6. M. C. Shaw, Metal Cutting Principles, 2nd Edition, Oxford University Press, 2005.
7. J. A. Goldak, Computational Welding Mechanics, Springer, 2005.
8. R. H. Wagoner and J. L. Chenot, Fundamentals of Metal Forming, Wiley, 2001.
9. G. E. Dieter, Mechanical Metallurgy, 3rd SI Edition, McGraw Hill Education, 2013.
10. U. S. Dixit and R. Ganesh Narayanan, Metal Forming: Technology and Process Modelling, McGraw Hill Education, 2013.
11. P. M. Dixit and U. S. Dixit, Modeling of Metal Forming and Machining Processes: By Finite Element and Soft Computing Methods, Springer, 2008.

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**MEMT514: Computer Aided Design and Manufacturing** **L-T-P-CH-CR: 3-1-0-4-4**

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**Introduction and Overview:** Components of Computer aided design (CAD), Components of Computer aided manufacturing (CAM).

**Basic concepts and Application of CAD:** Introduction to Computer Graphics, Basic concept of graphics: Graphics System Hardware requirements: Input devices, output devices, Graphics software, Graphical user interface; Viewing Pipeline, Windowing and Clipping, Window to Viewport Mapping, Line Drawing Algorithms: DDA and Bresenham's algorithm, Programming; Rendering Graphical user interface; Computer aided drafting systems.

**Transformation (2D/3D):** Representation and transformation of points, homogeneous coordinates, rotation, reflection, translation, scaling and sharing of lines, combined transformation, solid body transformation.

**Projections:** Orthographic, axonometric, oblique and perspective projections.

Plane curves: Parametric and nonparametric curves like circle, ellipse, parabola and hyperbola; Conic sections.

**Space curves:** Cubic splines, parabolic blending, Bezier curves and B-spline curves.

Surface Generation: surface of revolution, sweep surface, quadric surface, bilinear surface, ruled and developable surfaces, Coons linear surface, Coons bicubic surface, Bézier surface, B-spline surface and composite surface.

**Solid body modelling:** Designing 3D models like machine parts, hidden line and surface removal.

Numerical control in CAM: Concepts for manual and computer assisted part programming; NC, CNC, DNC, Adaptive Control Systems, Virtual engineering - components and applications.

**Additive manufacturing**

**Flexible manufacturing system (FMS)**

**Group technology:** Rank Order Clustering Algorithm, Classification and Coding Introduction to Computer Integrated Manufacturing (CIM) and Computer Aided Process Planning (CAPP)

**Modelling and Analysis software:** CAD modelling, CAM software practices, assignment and mini-project.

**Text Books:**


1. Kunwoo Lee, *Principles of CAD/CAM/CAE systems*, Addison Wesley, 1999.
2. Mikell P. Groover and Emory W. Zimmers, *CAD/CAM: Computer aided design manufacturing*, Prentice Hall, 1996.


**Reference Books:**


1. Mark E. Coticchia, George W. Crawford, and Edward J. Preston, *CAD/CAM/CAE systems: justification, implementation and productivity measurement* , 2nd edition, New York, Marcel Dekker, 1993.
2. Chris Macmahon and Jimmie Browne *CAD-CAM: principles, practice and manufacturing management*, 2nd edition, Addison Wesley, 1998.
3. P. Radhakrishnan, S. Subramanyan, and V. Raju ,*CAD/CAM/CIM* , 2nd edition, New Age.
4. Rogers, D.F. and Adams, J.A. *Mathematical Elements for Computer Graphics* (Tata McGraw-Hill, 2002).
5. Mortenson, M.E. *Mathematics for Computer Graphics Applications* (Industrial Press,1999).
6. Ryan, D.L. *Computer-Aided Graphics and Design* (Marcel Dekker, 1994).

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**MEMT584: Automation in Manufacturing** **L-T-P-CH-CR: 3-0-1-5-4**

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**Module-I: Introduction**

Industry 4.0 and Society 5.0. in regard to Automation; Overview of Manufacturing and Automation - Production systems, Manufacturing support systems, Automation in production systems, Automation principles and strategies, Reasons for Automation, Manufacturing operations, Functions in Manufacturing. Basic elements of an automated system, levels of automation; Components & classifications - basic elements of an automated system, levels of automation; Automation in manufacturing systems, principles and strategies, mathematical models, costs. Fabrication or selection of various components of an automated system. [Lectures - 8]

**Module-II: Assembly and Flow lines**

Analysis of Automated flow lines: Assembly Systems and Line Balancing- Assembly process - Assembly lines-manual single stations assembly, Manual assembly line, automated assembly system-Line balancing. Group technology – parts families, classification and coding, Production flow analysis (PFA) procedure, Cellular manufacturing, Flexible manufacturing systems (FMS) – definition, classification, applications. [Lectures -10]

**Module-III: Materials handling and identification**

Automated material handling and storage system: Overview of equipment, types of equipment, functions, analysis and design of material handling systems - conveyor systems, automated guided vehicle systems. Automated storage systems, conventional and automated storage systems; Automated identification methodology – Bar- code technology, Radio Frequency Identification (RFID) technologies. [Lectures -10]

**Module-IV: Sensing and Inspection**

Sensors: study of various sensors required in a typical automated system for manufacturing. Construction and principle of operation. Drives: electrical drives – types, selection criteria, construction and operating principle. Mechanical drives: Electronic cams, indexing mechanisms, tool magazines, and transfer systems. Ball screws, linear motion bearings, cams, systems controlled by camshafts. [Lectures -6]

**Module-V: Automation and Control**

Pneumatic and Hydraulic systems – Overview of pneumatics and hydraulic systems; Actuators – linear actuators (hydraulic cylinders) and rotary (hydraulic motors) – types, applications and limitations; Control valves – types – pressure control, directional control and flow control valves; Accumulators – hydraulic accumulators – functions, types, Hydraulic intensifier, Electro-hydro servo systems, Moving part logic (MPL), Fluid logic control. [Lectures -08]

**Module-VI: Industrial Automation and PLCs**

Programmable Logic Controller (PLC)- Block diagram of PLC, Programming languages of PLC, Basic instruction sets, Design of alarm and interlocks. CNC technology: basic elements, interpolators and programming. Practical demonstration and hands on session on process control systems using PLC. [Lectures – 12]

**Text Books:**

1. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education, 2009.

**Reference Books:**

1. Computer Control of Manufacturing Systems, Y. Coren, McGraw Hill.

2. CAD/CAM/CIM, Radhakrishnan& Subramanian, Wiley Eastern.
3. Mechatronics, HMT Ltd. Tata McGraw-Hill, New Delhi, 1988.
4. Mechatronics: electronic control systems in mechanical and electrical engineering, W. Bolton, Longman, Singapore,1999
5. Sensors in manufacturing, H.K. Tonshoff and I. Inasaki, Wiley-VCH, 2001.
6. Computer - Based Industrial Control, Krishna Kant, 2nd Edition, Prentice Hall, New Delhi, 2011.

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**MEMT515: Experimental Methods in Design and Manufacturing L-T-P-CH-CR: 1-0-2-5-3**

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**Introduction to Computer-Aided Design and Analysis:** Basic Drafting, Modelling of Parts, Assembly design and Simulation, Parametric modelling.

**Applications to Finite Element Methods:** Basic engineering analysis of beams, trusses, plates; Stress analysis of structure with individual and combined loading; Sensitivity analysis; Solution to problem with Mechanical, Thermal and Thermo-Mechanical loading.

**Introduction to computational programming:** MATLAB Basics: Arrays and Matrix Operations, Functions, Graph Plotting, Introduction to different tool-boxes & Simulink; Introduction to Python.

**Advanced Material and manufacturing Techniques:** Microstructural analysis; Macro/micro-hardness measurement; Heat treatment technology; Advanced foundry practice; Advanced welding techniques; Machinability measurement; Advanced machining techniques: NC and CNC, Computer assisted part programming; Additive manufacturing; Inspection of the products; Industry 4.0 and lean six-sigma Integration.

**Experimental Methods:** Experimental measurement of force, torque, stress, strain, and displacement; Photo-elasticity and strain gauges.

**Metrology:** Study of surface profile; Dimensional error evaluation; Assessment of heat affected zone, etc.

**Statistical Analysis of Experimental Data:** Error analysis, Uncertainty analysis, Data reduction techniques, Probability distributions, Student's distribution, Hypothesis testing and Curve fitting.

**Case studies / Mini projects / Development of existing set-ups.**

**Text Books:**

1. Wheeler A.J. and Ganji, A.R. *Introduction to Engineering Experimentation* (Pren-tice Hall, 2003)
2. Chapman S. J. *MATLAB Programming for Engineers* (Cengage Learning, 2007)
3. Kalpakjian, S. and Steven, R.S. *Manufacturing Processes for Engineering Materials*. Pearson Education, 6th edition, 2018.
4. Ostwald, P.F. *Manufacturing Processes and Systems*. John Wiley & Sons. 9th edition, 2008.

**Reference Books:**

1. Kent L.L. *ANSYS Workbench Tutorial Release 14* (SDC Publications, 2012)
2. Doeblin E.O., *Engineering Experimentation* (McGraw-Hill, 1995).
3. Chapra S.C., *Applied Numerical Methods with MATLAB for Engineering and Science* (McGraw-Hill Science, 2004).
4. Callister, W. D. Material Science and Engineering - An Introduction. John Wiley & Sons, 7th edition, 2007.

5. Dieter, G. E. Mechanical Metallurgy. McGraw Hill, 3rd edition, 1988.
6. M. P. Groover *Automation, Production Systems and Computer-Integrated Manufacturing* Prentice Hall
7. Ghosh, A. and Mallik, A. K. *Manufacturing Science*. East West Press, 2nd edition, 2010.

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**MEMT530: Numerical Methods** **L-T-P-CH-CR: 3-0-1-5-4**

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**Roots of single-variable nonlinear equations:** Bracketing methods, bisection method, false position method, fixed point iteration, Netwon-Raphson method and secant method, solution of specific thermal engineeringrelated problems using some of the above methods
**Roots of singe-variable polynomials:** Polynomial deflation, Bairstow's method and Muller method
**Numerical differentiation:** Finite difference approximations of first and second order derivatives
**Numerical integration:** Newton-Cotes Methods, Gauss quadrature
**Linear system of equations:** Direct Methods: Gauss elimination, Gauss-Jordan method, matrix inversion, LU decomposition
**Iterative methods:** Gauss-Seidel, Jacobi, Relaxation methods
**Eigenvalues and eigenvectors:** Direct power method, inverse power method and shifted power method
**Similarity transformation:** QR decomposition with Householder transformation Numerical solution of nonlinear equations: Fixed point iteration, Newton's method
**Ordinary differential equations:** Euler and Runge-Kutta methods for initial value problem, shooting and finite difference methods for boundary value problems, predictor-corrector method, eigenvalue problems, solution of boundary layer equations using Newton Raphson method and 4th order Runge-kutta method
**Partial differential equations:** Classification of PDEs and their characteristics, parabolic, elliptic and hyperbolic equations, Numerical solution of parabolic, elliptic and hyperbolic equations
**Laboratory component:** The laboratory component will include computer programming of the methods described and some other assignments through which students will be able to acquire the skill of writing computer programs/codes on numerical algorithms and solving real life problems.

**Text Books:**

1. Gerald, C.F. and Wheatley, P.O. *Applied Numerical Analysis*, Addison-Wesley, USA, 5th ed., 1994
2. Conte, S.D. and de Boor, C. *Elementary Numerical Analysis*, McGraw-Hill, 3rd ed., 2005.
3. Hildebrand, F.B. *Introduction to Numerical Analysis*, 2nd ed., Courier Dover Publications, New York, 1987.

**Reference Books:**

1. Kreyszig, E. *Advanced Engineering Mathematics*, John Wiley & Sons, 10th ed., 2010.
2. Burden, R. L. and Faires, J. D. *Numerical Analysis*, Brooks/Cole, 9th ed., 2011.

## Elective Courses

**MEMT575: Advanced Materials for Design** **L-T-P-CH-CR: 3-0-0-3-3**

Advanced materials for modern Engineering Design: Metals, Polymers, Composites and Ceramics; Proper material selection for design considerations

Structure-property correlation for design purposes: Role of crystal structure, substructure and microstructure on material properties and machine design

Metallic alloys for high performance structural design and their applications, Surface engineering of materials and their applications

Applications of Piezoelectric materials, Shape memory alloys, Smart materials and Composite materials in design of modern engineering components

Micro-electro-mechanical systems (MEMS) for design: Characteristics of materials for MEMS applications and MEMS components

Designing components for high temperature applications: Various alloys and composites, Diffusion bond coating Application of Powder metallurgy technique in design: Selection of materials, Cost, Design and Manufacturing considerations involved

Advanced materials for design of Automobile and Transport vehicles, Aerospace, Power generation, Armament, Marine environment and Ocean structures, Materials for other specialized applications

Advanced material testing for machine design considerations

Assignment and mini-project.

**Text Books:**


1. Callister, W. D. *Material Science and Engineering - An Introduction.* John Wiley & Sons, 7th edition, 2007.
2. Mallick, P.K. *Fiber Reinforced Composites Materials, Manufacturing and Design*. Marcel Dekker, 2007.


**Reference Books:**


1. Otsuka, K. and Wayman, C.M. *Shape Memory Materials.* Cambridge University Press, 1999.
2. Gandhi, M.V. and Thompson, B.S. *Smart Materials and Structures.* Chapman and Hall, 1992.


**MEMT504: Failure Analysis of Materials** **L-T-P-CH-CR: 3-0-0-3-3**

Introduction, common causes of failure, failure investigation, principle of failure analysis;

Fracture mechanics - energy approach and stress intensity factor approach to linear elastic fracture mechanics, concept of crack tip opening displacement and J-integral fracture criteria, mechanisms of fracture, evaluation of fracture toughness, fracture in composite materials, computational fracture mechanics analysis, fracture mechanics in nano materials and structures;

Creep - stress-time-temperature relations, creep curve;

Fatigue - stresses in cyclic loading, fatigue testing, S-N curves and endurance limit, mechanisms of fatigue crack initiation and propagation, influence of stress concentration on fatigue strength, notch sensitivity, factors influencing fatigue behavior, prevention of fatigue failure;

Assignment and mini-project.

**Text Books:**

1. Kumar, P. *Elements of Fracture Mechanics* (McGraw-Hill, 2009)
2. Anderson, T.L. Fracture Mechanics: Fundamentals and Applications (CRC Press, 2004)

**Reference Books:**

1. Bruck, D. Elementary Engineering Fracture Mechanics (Springer, 1986)
2. Barson, J.M. and Rolfe, S.T. *Fracture and Fatigue Control in Structures* (Butterworth-Heinemann, 1999)
3. Dieter, G. *Mechanical Metallurgy* (McGraw-Hill, 1986)
4. Calister, W.D. *Material Science and Engineering: An Introduction* (John Wiley & sons, 2009)
5. Gdoutos, E.E. *Fracture of Nano and Engineering Materials and Structures* (Springer, 2006)

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**MEMT582: Heat Treatment Technology** **L-T-P-CH-CR: 3-0-0-3-3**

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Significance of heat treatment in material processing for manufacturing industries: Concepts of processing-structure- property co-relation

Phase diagrams:

Binary and ternary equilibrium diagrams; Phase rule and Lever rule; Nucleation and growth of phases; Determination of grain size; Fe-C phase diagrams; Decomposition of austenite: Diffusion controlled and diffusionless transformations; Pearlitic and Bainitic and Martensitic transformations; TTT and CCT curves

Heat treatment processes:

Recrystallization annealing: Effect of working on structure and properties of metals and alloys; Microstructural evolution and control; Recovery, Recrystallization and Grain growth; Recrystallization temperature, Critical deformation; Annealing and its classifications: Full annealing, Isothermal annealing, Diffusion annealing, Partial annealing, Subcritical annealing; Normalizing, Hardening, Tempering, Thermo-mechanical treatment; Surface Hardening: Carburizing, Nitriding, Electron Beam Hardening, Laser Hardening Heat Treatment of tool and alloy steels, cast irons; Heat treatment of weldments

Heat treatment of non-ferrous metals and alloys:

Cast and heat-treatable alloys; Theory of age-hardening and precipitation; Aging time and precipitation temperature on mechanical properties of alloys

Heat Treatment defects and their remedial measures

Heat treating furnace atmosphere: Automation and computerization of heat treating process & equipment

**Text Books:**

1. W. D. Callister, Material Science and Engineering - An Introduction, Wiley, 2002.
2. Rajan, T.V., Sharma, C.P., and Sharma, A. Heat Treatment Technology. PHI learning Pvt. Ltd. publication, Revised edition, 1997.
3. Sharma, R.C. Principles of Heat Treatment of Steels. New Age Int. (P) Ltd., 1996.

**Reference Books:**

1. Totten, G.E. Steel Heat Treatment: Equipment and Process Design. Taylor & Francis, 1st edition, 2006.

2. Chandler, H. Heat Treater's Guide: Practice and Procedures of Iron and Steels, ASM International, 2nd edition, 6th Printing, 2010.
3. Brooks, C.R. Heat Treatment, Structure and Properties of Nonferrous Alloys. ASM, 1982, Reprinted 1984.
4. Ostwald, P.F. Manufacturing Processes and Systems. John Wiley & Sons. 9th edition, 2008.

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**MEMT525: Tribology** **L-T-P-CH-CR: 3-0-0-3-3**

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**UNIT I** Introduction: Definition of tribology with examples, Tribological systems – economic benefits and importance, History of tribology, Modern applications of tribology, Role of surface roughness and elastic deformation in tribology.
**UNIT II** Wear: Introduction, Wear mechanisms – abrasive, adhesive, cavitation, corrosive, erosive, fatigue and fretting wear, Quantitative laws of wear, Measurement of wear, Wear analysis, Wear resistance materials. Friction: Causes of friction, Theories of friction – adhesion theory, junction growth theory; Laws of rolling friction, Measurement of friction, Methods of reducing friction.
**UNIT III** Lubricants and Lubrication: Introduction, Boundary lubrication, Hydrostatic, Hydrodynamic and Elasto- hydrodynamic lubrication, Mixed lubrication. Lubricants – types and properties of lubricants, lubricant additives, and
testing methods of lubricants. Contact systems: Principles and applications of Rolling contact bearings, Cams, Gears.
**UNIT IV** Bearings: Purpose, classification and properties of bearing, Failure modes of bearing, Bearing materials, Hydrostatic bearing lubrication – advantages & disadvantages; Hydrodynamic gas lubricated bearings.

**Text Books:**

1. Halling J., “Principles of Tribology”, The Macmillan Press Ltd, London, 1975.
2. Srivastava S.K., “Tribology in Industry”, S. Chand and Company, 2004.

**Reference Books:**

1. Hutchings IM, “Tribology, Friction and Wear of Engineering Material”, Edward Arnold, London, 1992
2. Wiliams J.A, “Engineering Tribology”, Oxford University Press, 2005.
3. Mazumdar B.C., “Introduction to Tribology of Bearings”, S. Chand and Company, 2010.

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**MEMT585: Advanced Machining Technology** **L-T-P-CH-CR: 3-0-0-3-3**

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**Machining process and principles:** Types of metal cutting; Mechanics of metal cutting; Chip formation: Types of chip produced, Chip thickness ratio and Shear angle; Machinability: Machinability criteria, Variables affecting machinability, Tests to determine machinability; Economics of machining.
**Cutting tool:** Tool geometry; Tool materials and properties; Classifications; Tool wear and tool life; Thermal aspects of machining; Cutting forces and power; Cutting fluids; Surface Integrity;

Sustainability aspects.

**Measurements** of Cutting force, Temperature, Tool wear and Surface roughness.

**Machine tools:** Classifications and specifications; Kinematics and structures of machine tools; Practical machining operations; Finishing operations.

**Machine tool automation:** Various semi-automatic and automatic machine tools; NC, CNC and DNC machines; Computer assisted part programming; FMS and CIM; Tool Condition monitoring; Adaptive control systems.

**Modern/Non-conventional machining methods:** Chemical, Electro-chemical, Electro-discharge, Ultrasonic, Laser, Plasma arc, Electron beam, Abrasive and Water jet machining; Low-temperature machining; Advanced hybrid machining processes.

**Industry 4.0 technologies and their impact on machining processes; Case studies or industry examples.**

**Text Books:**

1. Milton C Shaw-*Metal Cutting Principles*. Oxford University press
2. M. P. Groover *Automation, Production Systems and Computer-Integrated Manufacturing* Prentice Hall
3. Hassan El-Hofy (2005) Advanced Machining Processes -Nontraditional and Hybrid Machining Processes- McGraw-Hill
4. McGeough, J. (1988). Advanced Methods of Machining. London, New York: Chapman and Hall.

**Reference Books:**

1. Ghosh, A. and Mallik, A. K. *Manufacturing Science*. East West Press, 2nd edition, 2010.
2. Kalpakjian, S. and Steven, R.S. *Manufacturing Processes for Engineering Materials*. Pearson Education, 6th edition, 2018.
3. Ostwald, P.F. *Manufacturing Processes and Systems*. John Wiley & Sons. 9th edition, 2008.
4. N.K. Mehta *Machine Tool Design* and *Numerical Control*, Tata McGraw-Hill Publishing.

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**MEMT579: Advanced Foundry Technology** **L-T-P-CH-CR: 3-0-0-3-3**

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**Critical review of some foundry operations:** Stages of casting; Pattern materials and allowances; Mould and Core practices: Materials and properties, Effect of process variables on property of core and mould making sand, Moulding factors in casting design, Metal-mould reaction; Mould and Core making machines: Mixer, Muller, Jolting, Squeezing, Jolt-squeezing, Slinging, Blowing and Shooting machines

**Metal melting:** Properties of liquid metals and their role in foundry technology: Thermal properties, Viscosity, Surface tension and Density; Melting furnaces for different types of metals and alloys: Electric arc furnace, Induction furnace, Rotary furnace, Cupola melting; Industrial melting practices and melt controls as adopted in case of Steel, Cast Iron and non-ferrous alloys; Binary and ternary equilibrium diagrams: Diffusional & diffusionless transformation, Concepts of structure-property-processing co-relation

**Technology of Ferrous castings:** Fe-C phase diagrams; Classification, properties and applications of steel and cast iron; Solidification behaviour and effect of alloy additions, De-oxidation and degassing of steel

**Technology of Non-Ferrous castings:** Non-ferrous alloys based on Al, Cu, Zn and Mg: Their properties and applications; Solidification and microstructure of important non ferrous alloys; Melt treatment: modification and grain refinement

**Solidification of metals and alloys:** Plane front solidification, Temperature gradient, Liquidus temperature profile and G/R ratio, Chworinov rule; Directional solidification: Controlling factors, Principles of Feeding, Gating and Risering, Design of gating system, Wlodawer system of determining feeder head requirements, Feeder head efficiency, Concept of feeding range; Casting grain structure and control: Ingot structure, Dendritic and cellular dendritic growth, Multiphase microstructures, Structure of casting as influenced by alloy constituents

**Various casting processes:** Special casting processes: Investment casting, Die casting, Centrifugal casting, Continuous casting, Full mould casting, Pressure casting, Vacuum shield casting, Shell mould casting and Composite moulds, Squeeze casting and semisolid metal forming

**Casting design and simulation**

**Cleaning, Fettling, Salvaging and Heat treatments of castings**

**Casting defect analysis and remedies:** Gas defects and their control: Simple and complex gases in metals; Inclusions and sand defects: Methods to prevent impurities from entering into castings; Shaping faults arising in pouring; Shrinkage defects during solidification in liquid phase, Contraction defects, Dimensional errors; Compositional errors and segregation: Micro & Macro segregation; Micro & Macro porosity and residual stresses in casting

**Inspection and testing of casting defects**

**Text Books:**


1. Beeley, P.R. *Foundry Technology*. Butterworth-Heinemann, 2nd edition, 2001.
2. Webster, P.D. *Fundamentals of Foundry Technology*. Portcullis Press, 1980.
3. Kurz, W. and Fisher, D.J. *Fundamentals of solidification*. Trans Tech Publications Ltd., 3rd edition, 1992.


**Reference Books:**


1. Heine, R., Loper, C. and Rosenthal, P. *Principles of Metal Casting*. McGraw Hill Education, 2nd edition, 2017.
2. Kalpakjian, S. and Steven, R.S. *Manufacturing Processes for Engineering Materials*. Pearson Education, 6th edition, 2018.
3. Ostwald, P.F. *Manufacturing Processes and Systems*. John Wiley & Sons. 9th edition, 2008.
4. Mukherjee, P.C. *Fundamentals of Metal casting Technology*. Oxford & IBH Pub. Co., 2nd edition, 1988.
5. Kumar, D. and Jain, S.K. *Foundry Technology*, CBS publishers, 1st edition, 2007.


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**MEMT580: Advanced Metal Joining Technology** **L-T-P-CH-CR: 3-0-0-3-3**

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**Introduction:** Theory and classification of welding and other joining processes

**Welding Technology:** Classifications; Review of major welding processes; Principles of Pressure and non-pressure welding, Fusion and non-fusion welding

**Arc welding**: Principle and striking of welding arc; Arc zones; Arc efficiency; Arc blow; Arc maintenance and stability

**Manual metal arc welding:** Equipment; Electrodes for structural steels; Coating constituents and

their functions, Types of coatings; Current and voltage selection for electrodes, Power sources, Influence of power sources on welding, Conventional transformers, Rectifiers; Metal transfer and Heat transfer; Wire arc additive manufacturing (WAAM)

**Submerged arc welding (SAW):** Process details; Consumables for welding mild steel; Variations in the process; Advantages and Applications

**Gas metal arc welding (GMAW) or MIG/MAG welding:** Process details; Electrode wires, sizes and current ranges; Shielding gases; Advantages and Applications

**Gas tungsten arc welding (GTAW) or TIG welding:** Process details; Power source, Electrode sizes and materials, Current carrying capacity of electrodes; Shielding gases; Advantages and Applications

**Electro-slag welding (EWS):** Principle, advantages and applications

**Plasma arc welding (PAW):** Principle, advantages and applications; Modes of operation

**Gas welding:** Oxy-acetylene welding (OAW): Principle, advantages and applications; Types of flames

**Resistance welding:** Principles; Process details and working principle of spot, seam, flash, butt, projection and percussion welding; Electrode materials and shapes, Electrode cooling, Selection of currents and voltages; Advantages and applications

**Thermit welding:** Principle, advantages and applications

**Modern welding processes:** Electron beam welding (EBW); Laser beam welding (LBW); Diffusion welding; Explosion welding; Ultrasonic welding; Friction stir welding: Friction Stir Processing

**Welding metallurgy of carbon and alloy steels, cast irons, stainless steels, Al and Cu based alloys:** Microstructural
evolution; Heat flow in welding: Heat affected zones

**Weldability:** Weldability of specific materials; Weldability tests

**Design of welded joints:** Welding positions; Weld design based on static, fatigue loading and fracture toughness

**Weld Defects:** Causes and corrective actions; Welding stresses and distortion; Imperfect shape or unacceptable contour; Cracks in welds; Incomplete fusion or penetration; Excessive spatter; Weld inspection: Detection techniques for weld defects; Non-destructive testing methods; Repair and maintenance of welding

**Brazing and Soldering:** Difference between Brazing, Braze welding and Soldering; Classification and methods of brazing and soldering; Filler metals; Consumables; Fluxes used, their purposes and flux residue treatment; Design and
process capabilities

**Text Books:**


1. Lancaster, J.F. *Metallurgy of Welding*. Woodhead Publishing, 6th edition, 1999.
2. Little, R. *Welding and Welding Technology*. McGraw Hill Education, 2017.
3. Norrish, J. *Advanced Welding Processes*. Woodhead publishing, 1st edition, 2006.


**Reference Books:**


1. Kalpakjian, S. and Steven, R.S. *Manufacturing Processes for Engineering Materials*. Pearson Education, 6th edition, 2018.
2. Kalpakjian, S. and Steven, R.S. *Manufacturing Engineering and Technology*. Pearson Education, 7th edition, 2018.
3. Ostwald, P.F. *Manufacturing Processes and Systems*. John Wiley & Sons. 9th edition, 2008.

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**MEMT581: Advanced Metal Forming Technology** **L-T-P-CH-CR: 3-0-0-3-3**

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**Mechanical working fundamentals:** Hot, warm and cold working; Role of temperature, strain rate, friction and lubrication in metal working; Effect of working on structure and properties of metals and alloys: Microstructural evolution and control; Recovery, Recrystallisation and Grain growth; Concept of workability and its evaluation: Processing maps

**Elements of theory of plasticity:** Elementary theories and calculation of working load and power; Formulation of metal forming problems and different methods of solution; Applications of upper bound method for solving problems, Slip line theory and its applications

**Forging Technology:** Open and closed die forging: Manufacturing of typical components; Factors affecting metal flow in the die: Forgeability, Die design; Friction and Lubrication; Load and energy characteristics; Classification and Characterization of forging equipments: Classification, designation, metallurgical characteristics and applications of ferrous and nonferrous alloys; Forging defects and remedial measures: Recent Trends in Forging Technology: Net-shape technology; Powder forging; Precision forging; Flash less forging etc.

**Rolling Technology:** Classification of rolling mills; Theories of hot and cold rolling;Principles of modeling rolling processes: Pass design; Calculation of Geometrical relationships, Forces, Rolling load, Torque, and Power equations; Friction, Lubrication and Thermal aspects; Rolling Mills; Automatic control of mills;

Types of rolled products; Defects in rolled products; Cooling and de-scaling of products

**Other mechanical working processes:** Principles, equipment and manufacturing methods of Extrusion, Wire drawing and Tube making; Advances in sheet metal forming; Hydro-forming of sheets and tubes; Special working processes:

Super plastic forming, High energy forming and Controlled rolling

**Text Books:**


1. Dieter, G.E. *Mechanical Metallurgy*. McGraw Hill Education, 3rd edition, 2017.
2. Harris, J.N. *Mechanical working of metals, Theory and practice*. Pergamon, 2013.


**Reference Books:**


1. *Forming and Forging*, Metals Hand book. ASM, Vol. 14, IX edition.
2. Kalpakjian, S. and Steven, R.S. *Manufacturing Processes for Engineering Materials*. Pearson Education, 6th edition, 2018.
3. Kalpakjian, S. and Steven, R.S. *Manufacturing Engineering and Technology*. Pearson Education, 7th edition, 2018.
4. Ostwald, P.F. *Manufacturing Processes and Systems*. John Wiley & Sons. 9th edition, 2008.


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**MEMT521: Robotics** **L-T-P-CH-CR: 3-1-0-4-4**

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Introduction: A brief history; Types of robots; Basic principles in robotics; Notation.

Mathematical Representation of Robots: Position & orientation of a rigid body; Transformation between coordinate systems; Homogeneous transformation and its properties; Representation of joints; Representation of links using Denavit-Hartenberg parameters; Link transformation matrices.

Kinematics of Serial Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematics problem; Redundant manipulators.
Velocity Analysis and Statics of Manipulators: Linear and angular velocities of a rigid body; Linear and angular velocities of links in serial manipulators; Jacobian; Singularities of serial manipulators;
Statics of serial manipulators; Redundancy resolution.
Elements of Kinematics of Parallel Manipulators: Degrees of freedom; Direct kinematics problem; Inverse kinematic problem; Mobility of parallel manipulators; Jacobian, Statics & Singularity.
Dynamics of Manipulators: Forward and inverse dynamics of manipulators; Newton-Euler and Lagrangian formulations.
Trajectory Planning and Generation: General considerations in path description and generation; Joint space schemes; Cartesian space schemes.
Position and Force Control of Manipulators: Feedback control of a single-link manipulator; PID control of a multi-link manipulator; Non-linear control of manipulators; Partitioning a task for force and position control; Hybrid position/force controller; Stability analysis.
Elements of a Robot: Actuators, Transmission & Sensors.

**Text Books:**


1. Ghosal A. Robotics - Fundamental concepts & Analysis (Oxford university press, 2006)
2. Craig J. J. Introduction to Robotics - Mechanics & Control (Addison - Wesley Publishing Company, New York, 1986)


**Reference Books:**


1. Asada H. and Slotine J. E. Robot Analysis & Control (John Wiley & Sons, New York, 1986)
2. Nakamura Y. Advanced robotics - Redundancy & Optimization (Addison - Wesley Publishing Company, New York, 1991)
3. Merlet J.P. Parallel Robots (Kluwer Academic Publishers, Netherlands, 2000)


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**MEMT605: Hybrid Electric Vehicles** **L-T-P-CH-CR: 3-0-0-3-3**

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History of Electric Vehicles [1]- History of Hybrid Electric Vehicles, History of Fuel Cell Vehicles;
Vehicle Fundamentals [1]-General Description of Vehicle Movement, Resistance, Rolling Resistance, Aerodynamic Drag, Grading Resistance, Dynamic Equation, Tire–Ground Adhesion and Maximum Tractive Effort, Power Train Tractive Effort and Vehicle Speed, Vehicle Power Plant and Transmission Characteristics, Power Plant Characteristics,
Transmission Characteristics, Gear Transmission, Hydrodynamic Transmission, Continuously Variable Transmission, Vehicle Performance ,Maximum Speed of a Vehicle, Gradeability, Acceleration Performance, Operating Fuel Economy, Internal Combustion Engines, Fuel Economy Characteristics of Internal Combustion Engines, of Vehicle Fuel Economy, Techniques to Improve Vehicle Fuel Economy, Braking Performance, Braking Force, Braking Distribution on Front and Rear Axles;
Electric Vehicles [2]-Configurations of Electric Vehicles, Performance of Electric Vehicles, Traction Motor Characteristics, Tractive Effort and Transmission Requirement, Vehicle Performance, Effort in Normal Driving, Energy Consumption;
Hybrid Electric Vehicles [3, 5]-Concept of Hybrid Electric Drive Trains, of Hybrid Electric Drive

Trains Series Hybrid Electric Drive Trains, Parallel Hybrid Electric Drive Trains, Se -Coupling Parallel Hybrid Electric Drive Trains, Speed- Coupling Parallel Hybrid Electric Drive Trains, Torque-Coupling and Speed-Coupling Parallel Hybrid Electric Drive Trains, Mild Hybrid Electric Drive Train Design;

Electric Propulsion Systems [2,4]-DC Motor Drives, Principle of Operation and Performance ,Combined Armature Voltage and Field Control, Chopper Control of DC Motors, Multiquadrant Control of Chopper-Fed DC Motor Drives, Two-Quadrant Control of Forward Motoring and Regenerative Braking, Induction Motor Drives, Basic Operation Principles of Induction Motors, Steady-State Performance ,Volt/Hertz Control, Power Electronic Control, Field Orientation Control, Voltage Source Inverter for FOC ,Voltage Control in Voltage Source Inverter, Current Control in Voltage Source Inverter, Magnetic Brush-Less DC Motor Drives, Basic Principles of BLDC Motor Drives, Control of BLDC Motor Drives, Extension of Speed Technology, Switched Reluctance Motor and its drives;

Energy Storages [5]-Electrochemical Batteries, Fuel Cells, Reactions, Thermodynamic Voltage Specific Energy Specific Power, Energy Efficiency, Battery Technologies, Lead-Acid Batteries, Nickel-based Batteries, Nickel/Iron System, Nickel/Cadmium System, Nickel–Metal Hydride (Ni–MH) Battery, Lithium-Based Batteries, –Polymer (Li–P) Battery, Lithium-Ion (Li-Ion) Battery, Ultracapacitors, Features of Ultracapacitors, Basic Principles of Ultracapacitors, Performance of Ultracapacitors, Ultracapacitor Technologies, Ultrahigh-Speed Flywheels, Operation Principles of Flywheels, Power Capacity of Flywheel Systems, Flywheel Technologies, Hybridization of Energy Storages;

Fundamentals of Regenerative Braking [1]-Energy Consumption in Braking, Power and Energy on Front and Rear Wheels, Brake System of EVs and HEVs, Brake — Optimal Feel, Series Brake — Optimal Energy Recovery, Parallel Brake, Antilock Brake System (ABS)

**Text Books:**


1. Mehrdad Ehsani, Yimin Gao, Sebastien E Gay, Ali Emadi, Modern Electric , *Hybrid Electric and Fuel Cell Vehicles* (CRC Press, London, 2005)
2. Allen W.M. *Automotive Science and Mathematics* (Butterworth Heinemann, Netherlands, 2008)


**Reference Books:**


1. Ali Emadi, *Handbook of Automotive Power Electronics and Motor Drives* (Taylor and Francis, London, 2005)
2. Allen W M Bonnick, *Automotive Computer Controlled Systems, Diagnostic Tools and Techniques* (Butterworth- Heinemann, Netherlands, 2001)
3. James Larminie, John Lowry, *Electric Vehicle Technology Explained* (John Wiley and Sons, Ltd., New Jersey, 2006)


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**MEMT607: Soft Computing Technique in Engineering** **L-T-P-CH-CR: 3-0-0-3-3**

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Introduction to soft computing, hard computing, Need for soft computing;

Neurons and neural networks; Basic models of artificial neural networks – single-layer perceptron, multilayer perceptron; Radial basis function networks; SOM; Recurrent neural networks;

Training of neural network; Applications of neural networks in mechanical engineering;
Introduction to fuzzy sets, Fuzzy reasoning and clustering;
Optimization tools: Traditional and non-traditional, genetic algorithms, simulated annealing etc.; Combined techniques: Genetic Algorithms–Fuzzy Logic, Genetic Algorithms–Neural Networks, Neural Networks–Fuzzy Logic.
Support Vector Machine (SVM) - introduction, principle and application.

**Text Books:**


1. Pratihar D. K. Soft Computing (Narosa Publishing House, 2015)
2. Haykin S. Neural Networks: A Comprehensive Foundation (Pearson Education, 2nd ed., 2009)
3. Chen G. and Pham T.T. Introduction to Fuzzy Sets, Fuzzy Logic, and Fuzzy Control Systems (CRC Press, 2001)


**Reference Books:**


1. Dixit, P. M. and Dixit, U. S., Modeling of metal forming and machining processes: by finite element and soft computing methods, (Springer, 1st ed., 2008)
2. Deb K. Optimization for Engineering Design: Algorithms and Examples (Prentice Hall, 2006)
3. Aliev R.A. and Aliev R.R. Soft Computing and its Applications (World Scientific Publishing, 2001)


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**MEMT608: Mechatronics and Industrial Automation** **L-T-P-CH-CR: 3-0-0-3-3**

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Introduction to Mechatronics: Introduction, Elements of Mechatronics system, Applications.
Sensors and Actuators: Sensing principle, Electrical actuators, Hydraulic and Pneumatic actuators. Signal Processing: Signal conditioning devices, Protection, Conversion and pulse width modulation, Data conversion devices. Microprocessors: Introduction to microprocessors, Introduction to microprocessor programming, Internal architecture of 8085 microprocessor.
Principles of Automation Technology: Automation system components, Discrete manufacturing automation, Continuous process automation.
Programmable Logic Controllers (PLC): Industrial Control, Structure of PLC, Programming languages for PLC, Boolean logic for process control, Timers, Counters and other functions.
Feedback Control: Continuous and Time- Discrete control, On/Off control, PID control, Distributed Control System (DCS)
Man machine communication: Supervisory control and data acquisition (SCADA) Assignment and mini-project.

**Text Books:**


1. Bolton W. Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering (Pearson education, 2007)
2. Lamb F. Industrial Automation: Hands-On (McGraw-Hill Education, 2013)


**Reference Books:**


1. Appukuttan K.K. Introduction to mechatronics (Oxford University Press, 2007)
2. Stenerson J. Industrial automation and process control (Prentice Hall, 2003)

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**MEMT539: Optimization Techniques in Engineering** **L-T-P-CH-CR: 3-0-0-3-3**

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Introduction – definition and importance of optimization, basic terminologies, general problem formulation;
Single variable unconstrained optimization – first and second order optimality criteria, bracketing and refining optimum point, direct search methods, gradient-based search methods;
Multi-variable unconstrained optimization - first and second order optimality criteria, unidirectional search, direct search methods, gradient-based search methods;
Constrained linear programming problems – simplex method, duality in linear programming;
Constrained nonlinear programming problems - Kuhn-Tucker conditions, sensitivity analysis, penalty function methods, method of multipliers, direct search methods, sequentially linearized methods, feasible direction method, gradient-based search methods, quadratic programming;
Specialized algorithms for integer and geometric programming problems; Application of different optimization methods to mechanical design problems; Assignment and mini-project.

**Text Books:**

1. Deb, K. *Optimization for Engineering Design – Algorithms and Examples* (Prentice-Hall of India, 1995)
2. Arora, J.S. *Introduction to Optimum Design* (Academic Press, 2004)

**Reference Books:**

1. Belegundu, A.D. and Chandrupatla, T.R. *Optimization Concepts and Applications in Engineering* (Pearson Education, 1999)
2. Rao, S.S. *Optimization: Theory and Applications* (Wiley Eastern, 1984)