MECHANICAL ENGINEERING

B.E: MINOR ENGINEERING (3-D Printing and Design)

Sl. No.	Course Code	Title of the Course	Credits
1	M18ME 03/ M20ME 03	Rapid Manufacturing	3
2	M18ME 04/ M20ME 04	Manufacturing Systems Technology	3
3	M18ME 05/ M20ME 05	Introduction to robotics	3
4	M18ME 11/ M20ME 11	Principles of Industrial Engineering	3
5	M18ME 15/ M20ME 15	Additive Manufacturing Technologies	2
6	M18ME 16/ M20ME 16	Product Design and Development	1
7	M18ME 17/ M20ME 17	Basics Of Finite Element Analysis	2
8	M18ME 18/ M20ME 18	Electronics equipment integration and Prototype building	2
9	M18ME 19/ M20ME 19	Design Practice	2
10	M18ME 20/ M20ME 20	Computer Aided Design / Computer Aided Manufacturing	1
11	M18ME 21/ M20ME 21	Basics of Materials Engineering	3
12	M18ME 22/ M20ME 22	Computer numerical control of machine tools and processes	1
13	M18ME 23/ M20ME 23	Processing of Polymers and Polymer Composites	2
14	H18ME 01/ H20ME 01	Automation in Manufacturing	3
15	H18ME 03/ H20ME 03	Industrial Safety Engineering	3
16	H18ME 08/ H20ME 08	Functional and Conceptual Design	3
17	H18ME 10/ H20ME 10	Design for Quality, Manufacturing and Assembly	2
18	H18ME 14/ H20ME 14	Design Thinking - A Primer	1
19	H18ME 15/ H20ME 15	Innovation by Design	1
20	H18ME 33/ H20ME 33	Robotics and Control: Theory and Practice	2
21	H18ME 37/ H20ME 37	Foundations of Cognitive Robotics	1

M18ME 03/ M20ME 03

RAPID MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Define Rapid Manufacturing. (BL-1)
2. Understand Design for Modularity and the Reverse Engineering (BL-2)
3. Analyze and select a Rapid manufacturing technology for a given component. (BL- 4)
4. Describe the materials used and Post-processing techniques in Rapid Manufacturing. (BL-2)
5. Illustrate the significance of Rapid Product development. (BL-3)

UNIT- I

Introduction to Rapid Manufacturing (RM), Product Design Process

UNIT- II

Design for Modularity, Reverse Engineering, 3D measurement: laboratory demonstration

UNIT- III

Polymerization and Powder based RM processes, Liquid based, and Sheet stacking RM processes, 3D printing RM processes and laboratory demonstration

UNIT - IV

Beam Deposition RM processes, and materials in RM, Post-processing and costing in RM

UNIT –V

Rapid Product Development (CAD/CAE/CIM), Rapid Product Development (Software demonstration), and case studies on RM

Text Books:

1. Kamrani, A.K. and Nasr, E.A., 2010. Engineering design and rapid prototyping. Springer Science & Business Media.Groover, M. P., Automation, Production Systems, and Computer-Integrated Manufacturing, Prentice Hall, 2001.
2. Gebhardt, A., 2011. Understanding additive manufacturing.
3. Gibson, I., Rosen, D.W. and Stucker, B., 2014. Additive manufacturing technologies (Vol. 17). New York: Springer.

Suggested Reading:

1. Hopkinson, N., Hague, R. and Dickens, P. eds., 2006. Rapid manufacturing: an industrial revolution for the digital age. John Wiley & Sons.
2. Pham, D. and Dimov, S.S., 2012. Rapid manufacturing: the technologies and applications of rapid prototyping and rapid tooling. Springer Science & Business Media.

M18ME 04/ M20ME 04

MANUFACTURING SYSTEMS TECHNOLOGY

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Understand the concepts of computer aided designing. (BL-2)
2. Apply the principles in process planning. (BL-3)
3. Gain knowledge on computer numerical control systems. (BL-1)
4. Distinguish between quality improvement methods. (BL-4)
5. Understand the dynamic changes that are taking place in business environment. (BL-2)

UNIT- I

Introduction: Manufacturing properties of materials

Integrated product designing: Manufacturing systems approach, historical perspective of design, material handling systems.

Computer aided designing: Introduction, homogeneous transformation, 3-D transformations, parametric and non-parametric equations, hermite cubic spline fit, Bezier curves, introduction to manufacturing processes,

UNIT- II

Principles and process planning of basic machining processes, machine tools design.

Computer aided process planning: Developing a process plan, determining machining conditions and machining time, machining cost evaluation, estimation of tool life, generative CAPP method and knowledge based process planning.

UNIT- III

Introduction to CNC part programming, motion control of NC machines, preparatory functions used in NC programming, G codes, M codes and canned cycles.

UNIT - IV

Quality systems engineering: Introduction to quality engineering, Just-in-time manufacturing, toyta production system, pull systems, kanban systems. quality costs, product design, design of experiments, applications of quality loss function, product selection strategies.

UNIT –V

Cost of quality and statistical quality control: Robust design approaches, taguchi's method, failure mode and effects analysis, product quality improvement methods, quality tools, quality charts, X-bar chart, R-chart.

Robotic systems planning and designing: Six sigma, theory of probability, determining the defective products using probability, sampling based on permutations and combinations, bionomial distributions, poisson distribution, normal distribution, fundamental of robotics and its application in automated systems, joint configuration systems of robot.

Text Books:

1. R. Thomas Wright, "Manufacturing systems", Goodheart-Willcox Company, 1990.
2. Katsundo Mitomi , "Manufacturing Systems Engineering: A Unified Approach to Manufacturing Technology, Production Management and Industrial Economics", second edition, CRC press, 1996.
3. Yoram Koren , "Computer control of manufacturing systems", McGraw Hill ,2017

Suggested Reading:

1. Rao, Kundra, and Tewari, "Numerical Control and computer aided manufacturing", Mc Graw Hill ,2017

M18ME 05/ M20ME 05

INTRODUCTION TO ROBOTICS

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Describe the basic components, specifications and applications of the Robots (BL-1)
2. Understand transformations, direct and inverse kinematics of robots (BL-2)
3. Calculate forces in links and joints of a robot and find the singularities, Jacobian and trajectory planning of a robot for various tasks (BL-3)
4. Classify drives, sensors and grippers for various applications (BL-4)
5. Programme a robot for a given task with machine vision and sensors (BL-5)

Unit I

Introduction to robotics- History, growth; Robot applications- Manufacturing industry, defence, rehabilitation, medical etc., Laws of Robotics.

Unit II

Robot mechanisms; Kinematics- coordinate transformations, DH parameters Forward kinematics, Inverse Kinematics

Unit III

Jacobians, Statics, Trajectory Planning, Computed torque control, Actuators (electrical)- DC motors, BLDC servo motors.

Unit IV

Control – PWM, joint motion control, feedback control, Probabilistic robotics, Path planning, BFS; DFS; Dijkstra; A-star; D-star; Voronoi; Potential Field; Hybrid approaches

Unit V

Sensors , sensor integration. Perception, Localisation and mapping, Simultaneous Localization and Mapping. Introduction to Reinforcement Learning

Text Books:

1. Robert J Schilling, Fundamentals of Robotics, Prentice Hall India, 2000
2. John J Craig, Introduction to Robotics, Prentice Hall International, 2005
3. Groover, "Industrial Robotics", Mcgraw-Hill Publishing Company Ltd. 2003

Suggested Reading:

1. Asada and Slotine, "Robot analysis and Intelligence", Wiley Interscience, 1986
2. K.S. Fu Gon ZalezRC., lEEc.S.G., "Robotics, Control Sensing Vision and Intelligence", McGraw Hill, Int. Ed., 1987

M18ME 11/ M20ME 11

PRINCIPLES OF INDUSTRIAL ENGINEERING

Instruction	3 Hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Understand the various concepts of organizational structure. (BL-2)
2. Analyze the process layout design. (BL-4)
3. Apply the network techniques in the project management. (BL-3)
4. Apply forecasting techniques for predicting demand. (BL-3)
5. Apply the quality control tools to improve performance of production system. (BL-3)

Unit -I
Introduction: Developments, objectives, functions and tools.
Organizational structure: Roles, Types, product strategies, principles, process and product organization.

Unit-II
Plant Location and Plant Layout: Selection of site, Factor Affecting Selection of Site, Purpose and Types of Layout, Process Layout Design, Product Layout Design.
Material Handling: Scope, Capacity Planning &Scheduling, Sequencing, Relative Performance of Priority Sequencing Rules.

Unit-III
Inventory: Fundamentals, Models I, Models II, Wilson Model, Gradual Replenishment Model.
Project Management & Network Modeling: Introduction, Network Modeling, Network Analysis.

Unit-IV
Forecasting: Introduction, Methods I, Methods II, Methods III, Methods IV, Methods V.

Unit -V
Quality Control: Introduction, Fundamentals, Control Charts for variables, Control Charts for Attributes, Productivity & Work Study.

Text Books:
1. Russel, R S, Taylor BW, "Operations Management", Pearson education, 2003.
2. Jocobs C A ,"Production and operations management", TMH, 1999.
3. Mitra, A "Fundamentals of Quality control and improvement", John Willey & Sons, 2008.

Suggested Reading:
1. Besterfield DH, "Total Quality Management", Pearson education, 1999.
2. S.N. Chary, "Production and Operations Management", 3rd edition, Tata McGraw

M18ME 15/ M20ME 15

ADDITIVE MANUFACTURING TECHNOLOGIES

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Define Significance of manufacturing and Advances in Manufacturing (BL-1)
2. Explain various Additive Manufacturing Technologies and Industrial Applications. (BL-2)
3. Illustrate about different AM materials and Business Functionalities. (BL-3)
4. Identify Quality of parts and challenges in certification. (BL-3)
5. Interpret the impact of additive manufacturing on firms and market. (BL-2)

UNIT- I

Manufacturing Paradigms: Significance of manufacturing. Different manufacturing paradigms, craft production, mass production, mass customization, distributed manufacturing, servitisation. Technology and manufacturing.Laws of manufacturing.

Advances in Manufacturing and SCM: Additive manufacturing, and its impact over the product development cycles. Reconfiguring of supply chain models. Contemporary initiatives in manufacturing: Advanced Manufacturing (US), e-factory (Japan), Industrie 4.0 (Germany), Intelligent Manufacturing (China) and Make in India (India).

UNIT- II

Economics of Manufacturing: Firms' market microstructure for manufacturing. Economies of scale, unscale, and scope. Manufacturing production functions. Mathematics of complementarities.Complementarities in production.

Additive Manufacturing Technologies: Technology basics and classification. Metal additive manufacturing and significance of laser powder bed fusion. Challenges in realization of metal additive manufactured parts with adequate strength and integrity. Input data formats and data generation from physical artefacts. Build environment and concept of process window. Typical pitfalls and corrective measures.

Industrial Applications: Part Substitution, Prototyping, Tooling and Reengineering. Product Design and Development Models based on Metal Additive Manufacturing. Spare part management for engineering conglomerates and users of legacy systems. MRO and refurbishment models based on metal additive manufacturing.

UNIT- III

AM Materials: Functionalities of AM materials – metals, plastics, ceramics and composites.Use of certified Materials and challenges in adapting new materials. Comparisons of AM materials with cast or forged structural alloys. Common Defects in AM Parts and their implications

AM Business Functionalities: Essentials of AM plant infrastructure. Importance of post processing. Dimensional accuracy, surface finish and strength aspects.Powder handling and recycling.

Opportunities for Value Addition: Light Weighting, Part Consolidation and Topology Optimisation. Functional integration.

UNIT- IV

Quality: Process Certification, General Approach to Part Certification, Process Monitoring| Industry Certifications: AS, LR. Challenges in Certification and Prove Out Repeatability, Reliability and Predictability, Control Measures.

Opportunity Identification: Selection of Right Parts, Assessment of Shortlisted Components, Use Cases and Business Cases based on Techno-Commercials, Impact on Sub-systems and Systems

UNIT- V

Road Mapping: Challenges in AM Adoption and Change Management Approach, Wipro3D Adoption Approach, Benchmarking organizational Goals with reference to AM. Value Estimation. Economic characteristics of additive manufacturing.Impact of additive manufacturing on firms' payoff functions and market microstructure.

Manufacturing Architecture and Business Models for Manufacturing: Cloud manufacturing. Cooperative and responsive manufacturing.Data-driven manufacturing and digital factory. Human-centered manufacturing. Introduction to business models. Manufacturing-as-a-Service (MaaS).Anything-as-a-Service (XaaS).

Text Books:

1. Y. Koren, "The Global Manufacturing Revolution", John Wiley & Sons, 2010.
2. Richard D'Aveni, "The 3-D Printing Revolution", Harvard Business Review, May 2015.
3. John O. Milewski, "Additive Manufacturing Technologies", Springer, 2017

Suggested Reading:

1. Regtien, P. P. L., Sensors for mechatronics, Elesevier, USA, 2012.
2. Parr, A. A., Hydraulics and pneumatics, Elsevier, 1999.

M18ME 16/ M20ME 16

Product Design And Devlopment

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Define the needs of the customer while designing a new product or modifying existing product in the competitive environment. (BL-1)
2. Understand Product life cycle and value engineering. (BL- 2)
3. Make use of Ergonomic concepts in product design (BL- 3)
4. Understand design for manufacturability and assembly concepts in product design . (BL- 2)
5. Identify appropriate manufacturing technique . (BL-3)

UNIT- I

Product Design: Introduction to course, Need analysis, Product policy of an organization. Selection of a profitable product, Product design process, Product analysis.

UNIT- II

New Product Planning: Applications in product design, Problem identification and selection, Analysis of functions, Anatomy of function. Primary versus secondary versus tertiary/unnecessary functions, Functional analysis: Functional Analysis System Technique (FAST), Case studies. Product life-cycle, Value engineering in product design.

UNIT- III

Industrial Ergonomics: Introduction to product design tools, Quality Function Deployment, Computer Aided Design, Robust design, Design For Manufacturing, Design For Assembly, Ergonomics in product design.

UNIT - IV

Design for Manufacturability and Assembly: guidelines, Product design for manual assembly, Design guidelines for metallic and non-metallic products to be manufactured by different processes

UNIT –V

Process Selection: casting, machining, injection molding. Rapid prototyping, needs, advantages, working principle of Stereo lithography (SLA), Selective Laser Sintering (SLS),

Text Books:

1. B.W.Niebel &A.B.Draper, “Production Design & Process Engg”, McGraw Hill, Kogakusha, 1974.
2. A.K. Chitale& R.C. Gupta, “Product Design & Manufacturing”, PHI, 1997.
3. K. G. Swift & J. D. Booker, “Process Selection: From Design to Manufacture”, Butterworth-Heinemann Ltd; Revised 2/e, 2003.

Suggested Reading:

1. Brain Twiss, “Managing Technological Innovation”, Pittrnan Publications, 1992.
2. Karl T. Ulrich, Stephen Eppinger, “Product Design and Development”,McGrawHill Publication, 2012

M18ME 17/ M20ME 17

BASICS OF FINITE ELEMENT ANALYSIS

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Course Outcomes: At the end of the course, the students are able to

1. Analyze FEA models correct or not for 1D problems. (BL-4)
2. Apply FE method for solving field problems using Virtual work and Potential energy formulation (BL-3)
3. Solve radially symmetric problems. (BL-3)
4. Solve 1-D conduction and convection heat transfer problems and shear deformable beams (BL-3)
5. Solve time dependent problems, estimate natural frequencies for stepped bar, beam (BL-3)

UNIT- I

Finite element analysis (FEA): Introduction to FEA, philosophy of FEA, nodes, elements, shape functions, polynomials as shape functions, weighted residuals, elements and assembly equations, types of errors in FEA, overall FEA process, convergence, strengths of FE method, continuity conditions at interfaces.

UNIT- II

Mathematical Concepts and: Weighted integral statements, Gradient and Divergence theorems, functionals, variational operator, weighted integral & weak formulation: principle of minimum potential energy, variational method: Rayleigh Ritz method, weighted residual methods,

UNIT- III

1-D boundary value problems: FEA formulation for 2^{nd} order BVP, element level equations, Assembly of element equations, radially symmetric problems.

UNIT- IV

Heat transfer problems and Beams: 1-D heat transfer, 1-D heat conduction with convective effects, FE formulations of Euler Bernoulli beam, FE formulations of shear deformable beams, equal interpolation but reduced integration element.

UNIT -V

Time dependent and Eigen value problems: Introduction to time dependent problems, explicit and implicit method, diagonalization of mass matrix, spatial approximation, temporal approximation for parabolic and hyperbolic problems, FE formulations of dynamic systems, element mass matrices, Eigen value problems.

Text Books:

1. J.N.Reddy,"An Introduction to the finite element method" , Mc Graw Hill series in mechanical engineering, Hardcover – Import, 16 January 2005.
2. Tirupathi R Chandraputla and Ashok D Belagundu, "Introduction to Finite Elements in Engineering", Prentice Hall of India, 1997
3. Daryl L. Logan, "A First Course in the Finite Element Method", Cengage Learning, 2011.

Suggested Reading:

1. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt., "Concepts and Applications of Finite Element Analysis", 4/e, Wiley.
2. L. J. Segerlind, "Applied Finite Element Analysis", Wiley Eastern, 1984.

M18ME 18/ M20ME 18

ELECTRONICS EQUIPMENT INTEGRATION AND PROTOTYPE BUILDING

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Course objectives

1. Define the concepts of prototyping (BL-1)
2. Identify the concepts of solid modeling and 3D printing (BL-3)
3. Illustrate the hardware integration of electronic components (BL-2)
4. Identify the Fabrication and fastenings of components (BL-3)
5. Examine the Assembly and Finishing techniques (BL-4)

Unit 1

Product Concepts and Prototyping, Sample product concept and project

Unit 2

Solid Modelling and 3D printing

Unit 3

Detailing and design for 3D printing, Components and hardware integration

Unit 4

Fabrication and fastenings, Creative design of products

Unit 5

Assembly, Integration and Finishing techniques

Text books:

1. Eugene R. Hnatek, “Practical Reliability Of Electronic Equipment And Products”, Qualcomm Incorporated, san Diege, California

18MEM19/ M20ME 19

DESIGN PRACTICE

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Demonstrate the concepts of Product design (BL-3)
2. Apply the concepts of Concurrent Engineering (BL- 3)
3. Develop the Visualization of the Product Design (BL- 6)
4. Summarize the concepts of Group technology (BL- 2)
5. Select the material and ergonomics in design (BL- 4)

UNIT- I

Introduction to design /product design. Stanford model of Design thinking/ Stages of engineering design of products

UNIT- II

Introduction to Concurrent Engineering. Concurrent engineering in Practice

UNIT- III

Product embodiment design (robustness of design/FMEA techniques). House of quality, Specifications (Fits and Tolerances)

UNIT - IV

Axiomatic Design, Introduction to Group Technology, Creating forms and shapes, Geometric transformation models, Introduction to electronics.

UNIT –V

Material selection process in design, Applied Ergonomics (work systems design, Introduction to bio-mechanics)

Text Books:

1. Nanua Singh, “Systems approach to computer integrated design and manufacturing”, Wiley India Pvt. Ltd.1996
2. Karl T. Ulrich, Steven. D. Eppinger, “Product design and development”, Mcgraw hill publications.5th Edition,2011

M18ME 20/ M20ME 20

COMPUTER AIDED DESIGN / COMPUTER AIDED MANUFACTURING

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

Course Outcomes: At the end of the course, the students are able to

1. Understand CAD for drafting, modelling of curves. (BL-2)
2. Understand display devices and modelling techniques. (BL-2)
3. Demonstrate Numerical Control machines. (BL-2)
4. Develop programs using G and M codes for lathe and milling operations. (BL-3)
5. Describe various advanced manufacturing systems (BL-1)

UNIT- I

Introduction to Computer Aided Design (CAD): 2 D &3 D drafting, 3D modelling and CAD functions, applications, modelling of Curves, solids, mechanisms and assemblies.

UNIT- II

Display Devices, Working Principles and its various Techniques: Hardware and software of CAD, principles and techniques of CAD display devices, input and output devices, wireframe & solid modelling and its techniques, operations, comparison of wireframe & solid modelling.

UNIT- III

Introduction to CAM: Numerical control (NC), features and elements of NC, types of NC systems: PTP, straight cut and contouring.

UNIT- IV

Working principle of CNC machine: Computer numerical control machines (CNC), principles of CNC and coordinate systems, motion control, working and operation of CNC, advantages and disadvantages of CNC machines.

UNIT -V

Advanced manufacturing system: Position and flexible manufacturing systems (FMS), components and types, approaches, layouts, problems, advantages and disadvantages, automated guided vehicle systems (AGVS), types and control systems, charging and guidance methods, safety elements and task allocation and computer inventory control, management information systems (MIS), functions, storages and decision support systems (DSS) components and benefits, robotics, types of robots and features, robot anatomy, defining parameter, control systems and robot applications.

Text Books:

1. Groover, Mikell P and Zimmer's Emory W, "CAD/CAM", Prentice Hall India (P) Ltd, 2001.
2. Rao P N, "CAD/CAM: Principles and Applications", Tata McGraw Hill Higher Education P Ltd 2002.
3. Ibrahim Zeid, "Mastering CAD/CAM", Tata McGraw Hill Higher Education P Ltd 2004

Suggested Reading:

1. Radhakrishnan P, "CAD/CAM/CIM", New Age International Publishers 1994.
2. Groover, "Industrial Robotics", Mc Graw-Hill Publishing Company Ltd. 2003.

M18ME 21/ M20ME 21

BASICS OF MATERIALS ENGINEERING

Instruction	3 Hours per week
Course Duration	12 weeks
Credits	3

Outcomes: At the end of the course, the students are able to

1. Describe the relationship between structure and properties of materials. (BL-2)
2. Understand the mechanical behaviour of materials (BL-2)
3. Demonstrate knowledge relating to composition, structure and processing of materials. (BL-2)
4. Distinguish between plastic deformation and its different modes. (BL-4)
5. Apply the concepts of heat treatments to alter the structure and properties of materials. (BL-3)

UNIT-I

Crystal Structure: Introduction, Unit cells and Crystal Systems, Types of unit cells-ordination number, atomic packing factor and density computations, Single crystals, Polycrystalline materials-Ray diffraction – determination of crystal structure.

Imperfections in solids: Point defects,Impurities,Dislocations,Bulk or volume defects, Dislocations and strengthening mechanisms, slip in single crystals, critically resolved shear stress, Plastic deformation in polycrystalline materials, Deformation by twinning, Strengthening mechanisms.

UNIT-II

Mechanical properties of metals: Tensile test, compression test, shear and torsion test, Elastic deformation, Stress-strain plot, engineering and true stress-strain plots, relations between true and engineering values, Young's modulus, relation between elastic constants, Hooke's law. Plastic deformation, yielding and yield strength, tensile strength, ductility, resilience and toughness, elastic recovery, Hardness, Brinell, Rockwell and Vickers's hardness.

UNIT-III

Failure of materials: Introduction,Stress concentration factors, Stress tensor and its invariants, Static failure theories, Application of failure theories, Fracture mechanics, Griffith criterion. Fatigue failure theories, Low cycle and high cycle fatigue.

UNIT-IV

Phase diagrams: Introduction,solidus line, liquidus line, components of a typical phase diagram, Interpretation of binary phase diagrams of simple alloy systems, Determination of phases, amounts and composition of each phase, Iron-Iron Carbide (Fe-Fe_3C) Phase diagram, Influence of alloying elements like (Chromium, Nickel and Titanium) on the Iron-Iron carbide phase diagram.

UNIT -V

Heat treatment of Steel: Isothermal transformation diagram, Microstructural changes during phase transformation, Different types of microstructures formed during heat treatment and their relative hardness and mechanical properties: Fine Pearlite, Coarse Pearlite, Bainite, Martensite, Tempered Martensite
Continuous cooling transformation diagram, Types of heat treatment and associates microstructure,
Annealing, Tempering, Normalizing, Quenching, Spheroidizing.

Text Books

1. William D Callister Jr. and David G. Rethwisch, "Materials Science and Engineering:", 8th Edn ,2009.
2. S.H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill Publishers, 2nd Edn, 2005.
3. V. Raghavan, "Materials Science and Engineering", Prentice Hall of India Ltd, 4th Edn, 2005.

Suggested Readings

1. E. Dieter, “Mechanical Metallurgy”, Metric Edition, Tata McGraw Hill, 3rd Edn, 2005.2 2.K.L. 2. Kakani,” Material Science”, New Age Publications (P) Ltd, 2008.
2. Kakani, “Material Science”, New Age Publications(p) Ltd, 2008.

M18ME 22/ M20ME 22

COMPUTER NUMERICAL CONTROL OF MACHINE TOOLS AND PROCESSES

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Demonstrate computer numerical control machines. (BL-2)
2. solve the problems on CNC controls (BL-3)
3. Develop programs using G and M codes for lathe and milling operations. (BL-3)
4. Develop programs on interpolations. (BL-3)
5. Describe methods for cutter path generation of curved surfaces. (BL-1)

UNIT- I

Computer Numerical Control Machines: Introduction to computer control-role of computers in automation, binary logic and logic gates, classification of CNC machine tools, point to point control, continuous control, closed loop and open loop control, problems CNC on controls.

UNIT- II

Technologies and devices employed in CNC machines: Stepper motors, permanent magnet DC motors, binary circuits, decoders, tachogenerator, printed circuit motors, encoders, programs using G codes and M codes.

UNIT- III

2-D Programming and Interpolation: Computer aided offline programming, linear interpolations, curvilinear interpolations, programming on interpolation.

UNIT - IV

3-D programming: 3-D machining, basic concepts, curved surface geometry.

UNIT –V

Cutter path generation methods for curved surfaces: Iso parametric method, iso planar method, iso scallop method

Text Books:

1. Yoram Koren , “Computer control of manufacturing systems”, McGraw Hill ,2017.
2. Rao, Kundra, and Tewari, “Numerical Control and computer aided manufacturing”, Mc Graw Hill ,2017.
3. Albert Malvino, “Digital computer electronics”, 3rd edition, Tata McGraw Hill, 1992.

Suggested Reading:

1. D. Rogers and R. Adams, “Mathematical elements in computer graphics”, Mc Graw Hill ,2017.
2. Yoramkoren, “Computer Control of Manufacturing Systems” McGraw Hill Int, New York, 1994.

M18ME 23/ M20ME 23

PROCESSING OF POLYMERS AND POLYMER COMPOSITES

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

Outcomes: At the end of the course, the students are able to

1. Understand the classification of engineering materials, structure and mechanical properties of thermoplastics and thermosets. (BL- 2)
2. Select suitable method for manufacturing a plastic component (BL- 5)
3. Understand the basic concepts of composites and their classification (BL- 2)
4. Describe and differentiate various processing techniques used for polymer composites (BL-2)
5. Outline some important secondary processes used in the manufacturing of polymer composites (BL-4)

UNIT- I

Introduction: Engineering materials and processing techniques, thermoplastics and thermosets

Processing of polymers: Introduction and classification**,** thermoforming process, extrusion and compression molding

UNIT- II

Processing of Polymers: Injection molding, transfer molding, rotational molding and blow molding,

Composite materials: Basic concepts and classification of composite materials

UNIT- III

Processing of polymer composites: Hand-layup, spray-layup, compression molding, injection molding. reaction injection molding, autoclaving, resin transfer molding, filament winding, pultrusion

UNIT - IV

Processing of polymer composites: Sheet molding, pre-pegging and challenges in primary processing of composites,

Secondary processing of polymer composites: Joining of polymer composites, Adhesive joining. Mechanical joining, Microwave joining, Induction and resistance welding

UNIT –V

Drilling of polymer composites: conventional v ultrasonic drilling, remedies for reducing drilling induced damages, research tools for secondary processing, numerical problems and case studies

Text Books:

1. Mikell P. Groover, "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", Wiley publications, 6th edition 2015.
2. Kalpakjian, "Manufacturing Engineering and Technology", Pearson publications, 7th edition 2013.
3. P.N. Rao, "Manufacturing Technology", Vol.-1, McGraw Hills Publication, 4th Edition 2016.

Suggested Reading:

1. R.K.Rajput, "A text book of Manufacturing Technology", Vol-I, Laxmi Pub., 2007.
2. P.C. Sharma, "A Text book of Production Technology", 8/e, S. Chand & Co., Pvt.Ltd., 2014.

H18ME 01/ H20ME 01

AUTOMATION IN MANUFACTURING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Explain the design and development of automated systems in the manufacturing. (BL-2)
2. Describe working of various blocks of automated system. (BL-2)
3. Illustrate the principle of operation and construction details of sensors/transducers, actuators, drives and mechanisms, hydraulic and pneumatic systems for automation. (BL-3)
4. Summarize the microprocessor technology, programming and CNC technology. (BL-2)
5. Use automation principles for manufacturing industrial applications. (BL-3)

UNIT- I

Introduction: Importance of automation in the manufacturing industry. Use of mechatronics, systems required.
Design of an automated system: Building blocks of an automated system, working principle and examples.

UNIT- II

Fabrication: Fabrication or selection of various components of an automated system, specifications of various elements, use of design data books and catalogues.
Sensors: Study of various sensors required in a typical automated system for manufacturing, construction and principle of operation of sensors.

UNIT- III

Microprocessor technology: Signal conditioning and data acquisition, use of microprocessor or micro controllers, configurations, working.
Drives: Electrical drives, types, selection criteria, construction and operating principle.

UNIT - IV

Mechanisms: Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, and transfer systems.
Hydraulic systems: Hydraulic power pack, pumps, valves, designing of hydraulic circuits.

UNIT –V

Pneumatic systems: Configurations, compressors, valves, distribution and conditioning.
CNC technology: Basic elements, interpolators and programming.

Text Books:

1. Boltan, W., “Mechatronics: electronic control systems in mechanical and electrical engineering”, Longman, Singapore, 1999.
2. Groover, M.P., “Automation, Production Systems, and Computer-Integrated Manufacturing”, Prentice Hall, 2001.
3. Gaonkar, R.S., “Microprocessor architecture, programming, and applications with the 8085”, Penram International Publishing (India), Delhi, 2000.

Suggested Reading:

1. Regtien, P. P. L., “Sensors for mechatronics”, Elsevier, USA, 2012.
2. Parr, A. A., “Hydraulics and pneumatics”, Elsevier, 1999.

Handbooks:

1. Smid, P., “CNC Programming Handbook”, Industrial Press, New York, USA, 2008.
2. Rothbart, H. A., “CAM Design Handbook”, McGraw-Hill, 2004.
3. Norton, R. L., “Cam Design and Manufacturing Handbook”, Industrial press Inc, 2002.

18 ME H03/ H20ME 03

INDUSTRIAL SAFETY ENGINEERING

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Identify the causes for industrial accidents and suggest preventive measures for safety. (BL-2)
2. Use the concepts of engineering systems safety, dimensions of engineering systems safety.(BL-3)
3. Apply the principles of safety design and carry out analysis. (BL-3)
4. Design for engineering systems safety and control for safety. (BL-3)
5. Integrate safety with other operational goals such as quality and reliability. (BL-5)

UNIT - I

Introduction: key concepts, terminologies, and safety quantification, safety by design, hazard identification techniques (e.g., HAZOP, FMEA, etc.) .

UNIT - II

Fault tree and event tree analysis (qualitative & quantitative) and Bow-tie and quantitative risk assessment (QRA) .

UNIT - III

Safety function deployment, safety vs reliability, quantification of basic events (repair to failure, repair-failure-repair, and combined processes).

UNIT - IV

Systems safety quantification (e.g., truth tables, structure functions, minimal cut sets), human error analysis and safety.

UNIT – V

Accident investigation and analysis, application of virtual reality, OSHAS 18001 and OSHMS.

Text Books:

1. Komamoto and Henley, “Probabilistic Risk Assessment for Engineering and Scientists”, IEEE Press, 1995.
2. Heinrich et al., “Industrial Accident Prevention”, McGraw Hill, 1980.
3. Petersen D, “Techniques for safety management - A systems approach”, ASSE 1998.

Suggested Reading:

1. H. P. Garg, “Maintenance Engineering”, S. Chand and Company, Year 2010.
2. Tyler G. Hicks and T. W. Edwards, “Pump Application Engineering", McGraw-Hill, 1971.

H18ME 08/ H20ME 08

FUNCTIONAL AND CONCEPTUAL DESIGN

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Outcomes: At the end of the course, the students are able to

1. Learn the importance of system design process in product design. (BL-1)
2. Identify various steps involved in the design process. (BL-2)
3. Learn the importance of function and form in the design process. (BL-1)
4. Apply the systematic design process for product development. (BL-3)
5. Apply the concept development tools in the design process. (BL-3)

UNIT - I
Overview of the design process: How engineering design is different from conventional design.
Steps in design process: Understanding the opportunity, mission statement.

UNIT - II
Customer need identification: Like/Dislike method, affinity diagram.
Product specifications: Design metrics, bench marking, QFD, HOQ and examples.

UNIT - III
Functional design: Functional decomposition, FAST, function structure, function tree, functional decomposition, examples.

UNIT - IV
Product architecture: Portfolio architecture, unshared, modular, customizable architectures, choosing portfolio architecture, module heuristics.

UNIT - V
Concept development: Converting functions to concepts, concept development tools- intuitive and logical methods, brainstorming, 6-3-5, TRIZ.
Concept selection: Concept screening, scoring and ranking.

Text Books:

1. Kevin Otto & Krisitn Wood, “Product Design”, Pearson Education, 2010.
2. D.G. Ullman, “The Mechanical Design Process”, McGraw- Hill, 2015.
3. G. Pahl and W.Beitz, “Engineering Design- A systematic Approach”, Springer, 2007.

Suggested Reading:

1. Michael Joseph French, “Conceptual Design for Engineers”, Springer; 3rd edition, 2013.
2. Clive L. Dym, “Engineering Design: A Project-Based Introduction”, Wiley; 4th edition, 2013.

H18ME 10/ H20ME 10

DESIGN FOR QUALITY, MANUFACTURING AND ASSEMBLY.

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

.**Outcomes:** At the end of the course, the students are able to

1. Recall the concepts such as quality, robustness, six sigma and orthogonal array. (BL-1)
2. Understand the limitations of a design from manufacturing and assembly perspective. (BL-2)
3. Suggest techniques to produce high quality products at low cost. (BL-4)
4. Design teams in simplifying product structure to reduce manufacturing & assembly costs and quantify improvements. (BL-4)
5. Interpret the reasons for variability, mathematically represent, formulate and control it. (BL-6)

UNIT - I

Introduction: Discussion on quality**,** measuring quality, quality loss function, discussion on robustness, six sigma concepts.

UNIT - II

Quantifying robustness: Signal to noise ratio, problem formulation using SNR, design of experiment discussions, orthogonal array, linear graphs, triangular tables, finding optimum combinations, case studies.

UNIT – III

Design for manufacturing: Over the wall design, most influential phase in design, best practices in injection molding and sheet metal working, design for additive manufacturing, single point and multipoint tools.

UNIT – IV

Design for assembly: Boothroyd Dewhurst method, theoretical minimum number of parts, Xerox producibility index (XPI) method.

UNIT – V

Do's and dont's in manual assembly, assembly time estimation, design for robotic assembly considerations, design for sustainability.

Text Books:

1. J. M. Juran, "Juran on Quality by Design: The New Steps for Planning Quality into Goods and Services", McGraw-Hill Education, 1992.
2. Daniel E. Whitney, "Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development", Oxford University Press, 2004.
3. Geoffrey Boothroyd, Peter Dewhurst, "Product Design for Manufacture and Assembly (Manufacturing Engineering and Materials Processing)", CRC Press, 3/e , 2010.

Suggested Reading:

1. James Bralla, "Design for Manufacturability Handbook", McGraw-Hill Education, 2/ e,1998
2. David M. Anderson , "Design for Manufacturability: How to Use Concurrent Engineering to Rapidly Develop Low-Cost, High-Quality Products for Lean Production", Productivity Press, 1/e, 2014.

H18ME 14/ H20ME 14

DESIGN THINKING - A PRIMER

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Understand the basic concept of design thinking. (BL-2)
2. Recall the step involved in design thinking. (BL-1)
3. Apply the principles of design thinking by observing, interviewing or just experiencing a situation. (BL-3)
4. Improve the situation of the humans by solving problems facing them. (BL-5)
5. Analyze problems using brain storming, 5 why's. (BL-3)

UNIT-I
Design thinking: Introduction, history, discussion and case study.

UNIT-II
Empathize phase: Customer journey mapping.

UNIT-III
Analyze phase: 5-Whys, 5 whys-IIT stadium levels and solve-workshop I & II.

UNIT-IV
Solve phase: Ideation, free brainstorming.

UNIT-V
Make/Test phase: Customer reactions to prototype, finale and appeal for proposals.

Text Books:

1. Prof. Karl Ulrich, "Design: Creation of Artifacts in Society", University of Pennsylvania, 2011.
2. Tim Brown, "Change by Design" Harper Business Publication, 2013.
3. Idris Mootee "Design Thinking for Strategic Innovation", Adams Media publications, 2014.

Suggested Reading:

1. Bryan Lawson, "How Designer's Think: The design process demystified", Architectural Press, 2005.
2. Brown, Dan M, "Designing Together", New Riders, 2013.

H18ME 15/ H20ME 15

INNOVATION BY DESIGN

Instruction	3	Hour per week
Course Duration	4	Weeks
Credits	1	

Outcomes: At the end of the course, the students are able to

1. Find solutions to present day problems and challenges through innovation. (BL-4)
2. Formulate a design enabled by innovation. (BL-6)
3. Gain knowledge on the journey of a design idea from the identification of a problem to a final solution. (BL-2)
4. Learn the importance of innovation process requiring empathy, meticulous effort, constant user interaction and effective collaboration. (BL-1)
5. apply innovation to have positive impact on a large community of users. (BL-3)

UNIT-I

Introduction: The seven concerns, design thinking & collaboration, challenges to innovation, understanding users, arriving at design insights, prototyping for user feedback.

First C: The cause: Crossing the first pitfall, trial and error, user feedback for development, new users, new needs to meet.

UNIT-II

Second C: The context: The basic need, ingenious attempts, further insights, the working rig, concepts generation, experiencing the product.

Third C: The comprehension: Understanding constraints, positioning the product, exploring possibilities, understanding the technology.

UNIT-III

Fourth C: The check: The check and the cause, the product, the users and the context, the prototyping, user needs.

UNIT-IV

Fifth C: The conception: Synchronic studies, one product, many problems, concept clusters, from idea to product, prototyping, materials and technologies, collaborative efforts.

UNIT-V

Sixth C: The drafting: Recap, the manufacturing challenge, the user feedback, the iterative Process.

Seventh C: The connection: The seed for innovation, pinnacle for innovation, the Innovation timeline, the innovation, champions, the Innovation templates, the Serial Innovation.

Suggested References:

1. 7C's Link: http://www.idc.iitb.ac.in/~chakku/chakku7Cs.pdf
2. Collaborative Model For Innovation Link: http://www.idc.iitb.ac.in/~chakku/collaborative_model_for_innovation.pdf
3. Pitfalls in the Innovation process Link: http://www.idc.iitb.ac.in/~chakku/Pitfalls_in_the_innovation_process.pdf
4. Innovation By Design – Collaboration is the key to cross the Pitsfalls in the Innovation Process Link: http://www.idc.iitb.ac.in/~chakku/Innovation_by_Design.pdf

H18ME 33/ H20ME 33

ROBOTICS AND CONTROL: THEORY AND PRACTICE

Instruction	3 hours per week
Course Duration	8 weeks
Credits	2

Outcomes: At the end of the course, the students are able to

1. Understand the spatial transformations associated with rigid body motions. (BL-2)
2. Develop skill in performing kinematics and dynamic analysis of robot systems. (BL-3)
3. Analyze different robot manipulators. (BL-4)
4. Understand the concept of robot exoskeleton. (BL-2)
5. Examine the robot assisted percutaneous interventions. (BL-4)

UNIT-I

Introduction: Coordinate frames and homogeneous transformations-I, coordinate frames and homogeneous frames-II, differential transformations, transforming differential changes between coordinate frames.

UNIT-II

Robot kinematics: Manipulator model, direct kinematics, inverse kinematics, manipulator Jacobian.

Robot dynamics: Trajectory planning, dynamics of manipulator, manipulator dynamics multiple degree of freedom ,stability of dynamical system.

UNIT-III

Manipulator control and neural networks: Biped robot basics and flat foot biped model, biped robot flat foot and toe foot model, artificial neural network, neural network based control for robot manipulator.

UNIT-IV

Robotic exoskeletons: Introduction, force control of an index finger exoskeleton, neural control of a hand exoskeleton, neural control of a hand exoskeleton based on human subjects intention, redundancy resolution of human fingers using robotic principles, manipulability analysis of human fingers during coordinated object rotation ,kinematics of flexible link robots.

UNIT-V

Robot assisted percutaneous interventions : Experiments on robot assisted percutaneous interventions, sliding mode control, higher order sliding mode control, smart needles for percutaneous interventions-I , smart needles for percutaneous interventions-II.

Text Books:

1. Mittal & Nagrath, "Robotics and Control", Tata McGraw-Hill Education, 2003.
2. Schilling Robert J, "Fundamentals of Robotics: Analysis and Control", Prentice-Hall, 1990. (TJ211.S334)
3 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.

Suggested Reading:

1 Niku Saeed B, "An Introduction to Robotics Analysis, Systems, Applications", Prentice-Hall, 2001.
2 K S Fu,Ralph Gonzalez,C S G Lee, "Robotics: Control Sensing. Vision and Intelligence", Tata McGraw-Hill Education, 1987.

H18ME 37/ H20ME 37

FOUNDATIONS OF COGNITIVE ROBOTICS

Instruction	3 Hours per Week
Course Duration	4 Weeks
Credits	1

Course Outcomes: At the end of the course, the students are able to

1. Understand importance of cognitive robot and smart materials. (BL-2)
2. Explain about intelligence, thinking. (BL-2)
3. Develop knowledge of artificial intelligence related to robots . (BL-3)
4. Design intelligent systems. (BL-6)
5. Apply AI based approach to various systems . (BL-3)

UNIT-I

Introduction: Introduction to cognitive robotics and human robot interaction, smart materials I, II, III.

UNIT-II

Intelligence thinking: Thinking, cognition, and intelligence, defining intelligence - embodiment and its implications.

UNIT-III

Artificial intelligence and theory of intelligence: Role of neuroscience and bio robotics, synthetic methodology for intelligence.

UNIT-IV

Intelligent system design and cognition development: Properties of complete agents, agent design principle, developmental robot design, matching brain and body dynamics.

UNIT-V

Control of intelligent systems- ai based approach: Artificial neural networks (ANN), fuzzy logic, genetic algorithms and other nature inspired methods, optimal control using ANN.

Text Book

1. "Neuroscience", edited by Dale Purves, et al., published by Sinauer Associates.
2. Rolf Pfeifer and Josh Bongard, "How the body shapes the way we think-A New View of Intelligence", MIT Press.
3. Jitendra R. Raol, Ramakalyan Ayyagari, "Control Systems: Classical, Modern, and AI-Based Approaches", CRC Press.