MECHANICAL ENGINEERING

B.E: MINOR ENGINEERING (Manufacturing and Robotics)

Sl. No.	Course Code	Title of the Course	Credits
1	M18ME 01/ M20ME 01	Fundamentals of manufacturing processes	3
2	M18ME 02/ M20ME 02	Mechanism And Robot Kinematics	2
3	M18ME 03/ M20ME 03	Rapid Manufacturing	3
4	M18ME 04/ M20ME 04	Manufacturing Systems Technology	3
5	M18ME 05/ M20ME 05	Introduction to robotics	3
6	M18ME 06/ M20ME 06	Fundamentals of electronic device fabrication	1
7	M18ME 07/ M20ME 07	Principles of Metal Forming Technology	2
8	M18ME 08/ M20ME 08	Fundamentals Of Artificial Intelligence	3
9	M18ME 09/ M20ME 09	Theory and Practice of Non Destructive Testing	2
10	M18ME 10/ M20ME 10	Computer Integrated Manufacturing	3
11	M18ME 11/ M20ME 11	Principles of Industrial Engineering.	3
12	M18ME 12/ M20ME 12	Advances in welding and joining Technologies.	2
13	M18ME 13/ M20ME 13	Advanced Machining Processes	2
14	M18ME 14/ M20ME 14	Material Science and Engineering	2
15	H18ME 01/ H20ME 01	Automation in Manufacturing	3
16	H18ME 03/ H20ME 03	Industrial Safety Engineering	3
17	H18ME 05/ H20ME 05	Mathematical Modeling Of Manufacturing Processes	3
18	H18ME 12/ H20ME 12	Manufacturing Strategy	2
19	H18ME 33/ H20ME 33	Robotics And Control: Theory And Practice	2
20	H18ME 37/ H20ME 37	Foundations of Cognitive Robotics	1

M18ME 01/ M20ME 01

FUNDAMENTALS OF MANUFACTURING PROCESSES

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 manufacturing, need, scope, advantages, limitation, and application. (BL-2)
2. Demonstrate the understanding of various manufacturing processes. (BL-2)
3. Solve simple problems such as riser design and sheet metal calculations. (BL-3)
4. Compare various Manufacturing processes. (BL-4)
5. Choose suitable manufacturing process for a given component. (BL-5)

UNIT- I

Understanding Manufacturing, Fundamental Approaches of Manufacturing, Manufacturing Process Specific Advantages and Limitations, Material and Manufacturing Processes, Classification of Manufacturing Processes, Selection of Manufacturing Processes, Applications of Manufacturing Processes, Effect of Manufacturing Processes on Mechanical Properties, Break Even Analysis in Manufacturing Processes.

UNIT- II

Casting: Introduction and Suitability, Steps of Casting Processes, Casting: Terminology, Types of Pattern Allowances, Sand Moulding, Core and Core Prints, melt treatment, solidification.

Gating System: Elements of gating system, Yield and Riser Design. Cleaning of Castings, Casting Defects and their Preventions, Shell Mould Casting, Investment and Permanent Mould Casting.

UNIT- III

Metal Working Processes: Hot & Cold Working, Rolling, Forging, Extrusion, Wire Drawing.

Sheet Metal Operations: Types of Presses, Shearing, punching, blanking, notching, nibbling drawing, Types of Dies and Die sets

UNIT - IV

Material Removal Processes: Machining, Mechanism of Metal Cutting and Chip Formation, classification, Material Removal Processes, Types of Chips and Power Consumption, Heat Generation, Tool Failure and Tool Life, Tool materials, Cutting fluids, Grinding, internal and external surface grinding, centerless grinding designation and selection of grinding wheel, trueing and balancing, honing, reaming, lapping, polishing etc

Improving surface properties: Introduction, Surface modification processes, surface modification methods namely without change chemistry, changing chemical composition and development of coating and cladding.

UNIT –V

Joining of metals: Joining: approach, need, principle of fusion welding, gas welding, thermit welding, arc welding, common arc welding processes, resistance welding, Brazing, soldering , Weldability and welding defects, solidification of weld, weld discontinuities and their remedy.

Heat treatment processes : Heat treatment of steel and Aluminum alloys, Fe-C diagram, TTT diagram, and CCT diagram, heat treatment processes annealing, normalizing, quenching ,hardening and tempering,

Text Books:

1. P.N.Rao, “Manufacturing Technology”, Vol.1, 3/e, Tata McGraw HillPubl., 2011.
2. Amitabh Ghosh and Mallick, “Manufacturing Science”, 4/e, Assoc.East West Press Pvt. Ltd., 2011.
3. MikellP.Grover, “Fundamentals of Modern Manufacturing Materials, Processes and Systems”, 3/e, Willey A

Suggested Reading:

1. G.K.Lal and S.K.Choudhury,” Fundamentals of Manufacturing Processes” Alpha science international ltd., 2005.
2. Schey, “Introduction To Manufacturing Processes”, 2/e, McGraw -hill Education. 2015.

M18ME 02/ M20ME 02

MECHANISM AND ROBOT KINEMATICS

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

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

1. Identify the mechanisms of the robots (BL-1)
2. Analyze the displacement analysis of Robots -1 and Robots-II (BL-4)
3. Solve the displacement and velocity analysis of different robotics (BL-3)
4. Estimate the constrained mechanisms of different robots (BL-5)
5. Assess the Acceleration Analysis and do the force analysis (BL-5)

Unit 1
Introduction to Mechanisms and Robotics, Mobility Analysis-I, Mobility Analysis-II

Unit 2
Displacement Analysis: constrained mechanisms and robots-I, constrained mechanisms and robots-II

Unit 3
Displacement Analysis: constrained mechanisms and robots- III, Velocity Analysis: constrained mechanisms and robots-I

Unit 4
Velocity Analysis: constrained mechanisms and robots-II, constrained mechanisms and robots-III

Unit 5
Velocity Analysis: singularity and path generation, Acceleration Analysis, Force Analysis-I, Force Analysis-II, Coordinate Transformations and kinematics of serial robots

Text books

1. Jadran Lenarcic, Vincenzo Parenti-Castelli, “Advances in robotic kinematics 2018” springer proceedings in advanced robotics
2. Carl D. Crane, III, Joseph Duffy, “Kinematic Analysis of Robot Manipulators” cambridge university press, 2008
3. Xilun Ding, Xianwen Kong, Jian S. Dai, “Advances in Reconfigurable Mechanisms and Robots II” springer , 2015

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
(For those who have not taken ROBOTICS as their Open Elective)

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

Course Outcomes: At the end of the course, the students will be 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 06/ M20ME 06

FUNDAMENTALS OF ELECTRONIC DEVICE FABRICATION

Instruction	3	Hours per week
Course Duration	4	Weeks
Credits	1	

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

1. Recall the basic understanding of semiconductor devices. (BL-1)
2. Understand the current fabrication practices used in the semiconductor industry, along with the challenges and opportunities in device fabrication. (BL- 2)
3. Describe process evaluation, productivity and process yield. (BL- 2)
4. Understand the concept of clean room design and contamination in device fabrication. (BL-2)
5. Describe the integrated circuit fabrication and packaging along with practices and challenges. (BL- 2)

UNIT- I

Introduction and overview of semiconductor device fabrication

UNIT- II

Fabrication operations: Oxidation, doping, and lithography

UNIT- III

Fabrication processes: etching and growth. Process evaluation

UNIT - IV

Process yield, clean room design

UNIT –V

IC logic and packaging.

Text Books:

1. Semiconductor Materials, Devices and Fabrication, Parasuraman Swaminathan, Wiley India, 2017
2. Microchip Fabrication: A Practical Guide to Semiconductor Processing, 6th Edition, Peter Van Zant, McGraw-Hill, 2013
3. Advances in Silicon Carbide Processing and Applications, Stephen E. Saddow, Anant Agarwal, 2004.

Suggested Reading:

1. Fundamentals of Industrial Electronics edited by Bogdan M. Wilamowski, J. David Irwin, 2016
2. Fundamentals of Electronics: Book 1: Electronic Devices and Circuit Applications, By Thomas F. Schubert, Ernest M. Kim, 2015.

M18ME 07/ M20ME 07

PRINCIPLES OF METAL FORMING TECHNOLOGY

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 fundamental concepts of metal forming technology. (BL-2)
2. Apply theory of plasticity to understand the effect of various parameters in metal forming. (BL-3)
3. Use various analysis methods to determine flow stresses in metal forming operations (BL-3)
4. Describe and differentiate various bulk forming processes. (BL-2)
5. Understand the basic concepts of Powder metallurgy and its applications. (BL-2)

UNIT- I

Introduction to metal forming technology: Classification of metal working processes, Behavior of materials, concept of stress and strain, Hydrostatic and deviatoric stresses

UNIT- II

Introduction to theory of plasticity: Flow curve, yield criteria for ductile materials, plastic stress strain relationships, yielding and ductility during instability, effect of strain rate and temperature on flow properties

UNIT- III

Mechanics of metalworking: Analysis methods, determination of flow stresses in metal working, hot and cold working

Forging & Rolling: Introduction, classification and analysis of forging and rolling operations, defects in rolled and forged components,

UNIT - IV

Extrusion: Introduction, classification and Analysis of extrusion processes

Wire Drawing: Analysis of wire, tube and rod drawing processes

UNIT –V

Sheet metal working: Introduction and classification of sheet metal processes

Powder metallurgy forming: Procedure of powder metallurgy and its applications, methods of powder manufacturing

Text Books:

1. Serope Kalpakjian, “Manufacturing Engineering &Technology”, Prentice Hall; 2013
2. George.E. Dieter, “Mechanical Metallurgy”, SI Metric Edition, McGraw-Hill.
3. P.N. Rao, “Manufacturing Technology”, TMH, Pub., 2013.

Suggested Reading:

1. Roy A lindberg, "Processes And Materials Of Manufacture", PHI, 2017.
2. Avitzur, Metal Forming – Process and Analysis, Tata McGraw – Hill Co., New Delhi, 1977.

M18ME 08/ M20ME 08

FUNDAMENTALS OF ARTIFICIAL INTELLIGENCE

Instruction	3	Hours per week
Course Duration	12	Weeks
Credits	3	

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

1. Differentiate between a rudimentary Problem and an AI problem, it's Characteristics and problem solving Techniques. (BL-2)
2. Compare the various knowledge representation schemes of AI. (BL 4)
3. Analyze various reasoning and planning techniques involved in solving AI problems. (BL 4)
4. Understand the different learning techniques. (BL 2)
5. Apply the AI techniques in the field of mechanical engineering. (BL 3)

UNIT- I

AI and Problem Solving by Search: Introduction to Artificial Intelligence, problem solving as state space search, uniformed search, heuristic search, informed search, constraint satisfaction problems, searching AND/OR graphs, game playing, minimax + alpha-beta.

UNIT- II

Knowledge Representation and Reasoning: Introduction to knowledge representation, propositional logic, first order logic-I, first order logic-II, inference in first order logic-I, inference in first order logic-II, answer extraction, procedural control of reasoning.

UNIT- III

Reasoning under Uncertainty: Reasoning under uncertainty, Bayesian network, decision network.

UNIT - IV

Planning and Decision Making: Introduction to planning, plan space planning, planning graph and graph plan, practical planning and acting, sequential decision problems, making complex decisions.

UNIT –V

Machine Learning: Introduction to machine learning, learning decision trees, linear regression, support vector machines, unsupervised learning, reinforcement learning, learning in neural networks, deep learning: a brief overview.

Text Books:

1. Elaine Rich, Kevin Night, Shivashankar B Nair, “Artificial Intelligence”, 3/E, 2008, TMH
2. Russell Norvig, “Artificial Intelligence-Modern Approach”, 3/E, 2010, Pearson.
3. Nilakshi Jain “Artificial Intelligence, As per AICTE: Making a System Intelligent”, 2019, Wiley India

Suggested Reading:

1. Saroj Kaushik, “Artificial Intelligence”, 2012, Cengage Learning India.
2. Deepak Khemani, “A First Course in Artificial Intelligence”, 2017, TMH.

M18ME 09/ M20ME 09

THEORY AND PRACTICE OF NON DESTRUCTIVE TESTING

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 Non Destructive Testing techniques of Dye penetrant inspection and Magnetic particle inspection (BL-2)
2. Compare eddy current testing with other NDT methods (BL-2)
3. Identify different types of defects using ultra sonic testing (BL-2)
4. Analyze the radiograph to detect the defects by using principles of radiography (BL-4)
5. Interpret latest Techniques of NDT with other methods (BL-3)

UNIT- I

Introduction to NDT, Visual Optical methods, Dye penetrant testing, Basic principle, Types of dye and methods of application, Developer application and Inspection. Magnetic particle testing, Basic theory of magnetism, Magnetization methods, Field indicators, Particle application, Inspection.

UNIT- II

Eddy current testing: Basic principle; Faraday’s law, Inductance, Lenz’s law, Self and Mutual Inductance, Impedance plane, Inspection system and probes, System calibration.

UNIT- III

Ultrasonic testing: Basics of ultrasonic waves, Pulse and beam shapes, Ultrasonic transducers, Test method, Distance and Area calibration, Weld inspection by UT.

UNIT - IV

Radiography: X-rays and their properties, X-ray generation, X-ray absorption and atomic scattering.

Image formation: Image quality, Digital Radiography, Image interpretation, Radiation Shielding. Comparison and selection of NDT methods, concluding remarks.

UNIT –V

Acoustic emission testing: Basic principle, Sources of acoustic emission, Source parameters, Kaiser-Felicity theory, Equipment and Data display, Source location schemes.

Text Books:

1. Barry Hull & Vernon John, "Non Destructive Testing", 1988.
2. H J Frissell, "Non-Destructive Evaluation and quality control", ASM handbook-International Publication USA, 1989.
3. Dove and Adams, "Experimental Stress analysis and Motion Measurement", Prentice Hall of India, Delhi.

Suggested Reading:

1. "Non-Destructive Examination and Quality Control", ASM International, Vol.17, 9th edition 1989.
2. J. Prasad and C. G. K. Nair, "Non-Destructive Test and Evaluation of Materials", Tata McGraw-Hill Education, 2nd edition 2011.

M18ME 10/ M20ME 10

COMPUTER INTEGRATED 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. Understand the concepts of computer integrated manufacturing. (BL-2)
2. Apply various computer numerical control techniques. (BL-3)
3. Understand various CIM interface techniques. (BL-2)
4. Understand manufacturing systems in CIM. (BL-2)
5. Apply CIM concepts in additive manufacturing. (BL-3)

UNIT- I

Introduction: Computer integrated manufacturing, computer aided design and computer aided manufacturing.

UNIT- II

Computer Numerical Control: CNC machining, CNC tooling, CNC part programming.
Computer Aided Process Planning: Retrieval CAPP systems, generative CAPP systems.

UNIT- III

CIM Interfaces: Computer aided design versus computer aided manufacturing.
Data and Information in CIM: Automatic identification and data capture.

UNIT - IV

Manufacturing Systems: Manufacturing systems and their design, simulation of manufacturing systems.
Computer Aided Maintenance: Computer aided quality control, coordinate measuring machine.

UNIT –V

Computer Integrated Additive Manufacturing: Components of CIM, rapid manufacturing.
Advanced CIM techniques.

Text Books:

1. Chang, T.C. and Wysk, R.A., "Computer-aided manufacturing", Prentice Hall PTR, 1997

2. Xu, X., "Integrating Advanced Computer-Aided Design, Manufacturing, and Numerical Control", Information Science Reference, 2009.
3. Groover, M.P., "Automation, production systems, and computer-integrated manufacturing", Prentice Hall Press, 2007.

Suggested Reading:

1. S.Kant Vajpayee: "Principles of Computer Integrated Manufacturing", Prentice Hall India, 1998
2. Weatherall, A., Computer integrated manufacturing: from fundamentals to implementation. Butterworth-Heinemann, 2013.

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 Hill, 2006.

M18ME 12/ M20ME 12

ADVANCES IN WELDING AND JOINING 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. Recall the fundamentals of welding and joining processes. (BL-1)
2. Understand the basic concept of laser and electron beam welding for micro-joining and nano-joining in the development of miniature components. (BL-2)
3. Describe the basic knowledge of computational welding mechanics. (BL-1)
4. Understand welding metallurgy and the most recent advances in welding and joining technologies. (BL-2)
5. Develop the fundamental understanding of metal transfer in welding and metal printing. (BL-2)

UNIT- I

Fundamentals of welding and joining

UNIT- II

Laser and electron beam welding, solid state welding processes

UNIT- III

Computational welding mechanics, Micro-joining and nano-joining.

UNIT - IV

Welding metallurgy, Welding and joining of non-metals

UNIT –V

Metal transfer in welding and metal printing.

Text Books:

1. M-K Besharati-Givi and P. Asadi, "Advances in Friction-Stir Welding and Processing", Woodhead Publishing Limited, 2014
2. J. Norrish, "Advanced welding Processes", Woodhead publishing, 2006.
3. L-E Lindgren," Computational welding mechanics", Woodhead Publishing Limited, 2007.

Suggested Reading:

1. J. A. Goldak, "Computational welding mechanics", Springer, 2005.
2. Gibson, David W. Rosen, Brent Stucke, "Additive Manufacturing Technologies", Springer, 2009.

M18ME 13/ M20ME 13

ADVANCED MACHINING PROCESSES

Instruction	3 Hours per week
Course Duration	8 Weeks
Credits	2

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

1. Compare the machining and advanced machining process and recognize the need for advanced machining process. (BL-2)
2. Analyze the processes and the role of each process parameter during machining of various advanced materials (BL-4)
3. Illustrate constructional features, performance parameters, process characteristics, applications, advantages and limitations of advanced Machining process. (BL-3)
4. Classify mechanisms of material removal of various advanced machining processes. (BL-4)
5. Identify requirements to achieve maximum material removal rate and best quality of machined surface while machining various industrial engineering materials (BL-2)

UNIT 1:

Introduction to advanced machining processes and their classification, Ultrasonic machining and its modeling and analysis, Abrasive jet machining (AJM) ,Water jet cutting (WJC) and Abrasive water jet machining (AWJM)

UNIT 2:

Magnetic abrasive finishing (MAF) and its modelling, Abrasive flow finishing (AFF) and its modelling, Magnetorheological finishing (MRF), Magnetorheological abrasive flow finishing (MRAFF) and its modelling and analysis

UNIT 3:

Electric discharge machining (EDM): Principle, applications, process parameters, and modelling, Electric Discharge Grinding (EDG), Electric Discharge Diamond Grinding (EDDG), and Wire Electric Discharge Machining (W-EDM)

UNIT 4:

Laser beam machining (LBM), Plasma arc machining (PAM), Electron Beam Machining, Electro chemical machining (ECM): Principle, applications, and process parameters and modelling

UNIT 5:
Electrochemical Grinding (ECG), Electrostream Drilling (ESD), Shaped Tube Electrolytic Machining (STEM), Chemical machining (ChM)

Text Books:

1. V. K. Jain, Advanced Machining Processes, Allied Publishers, 2009
2. Gary F. Benedict, Nontraditional Manufacturing Processes, Taylor & Francis, 1987
3. J. A. McGeough, Advanced Methods of Machining, Springer, 1988

Suggested Reading:

1. Hassan El-Hofy, Advanced Machining Processes: Nontraditional and Hybrid Machining Processes, McGraw-Hill Prof Med/Tech, 2005.
2. V. K. Jain, Introduction to Micromachining, Alpha Science International Limited, 2010.

M18ME 14/ M20ME 14

MATERIALS SCIENCE AND ENGINEERING

Instruction	3	Hours per week
Course Duration	8	Weeks
Credits	2	

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

1. Understand the Crystallography (BL2)
2. Describes the Phase Diagram and Transformation (BL1)
3. Explain the Fe-C, TTT and CCT diagrams (BL2)
4. Categorize the Mechanical Properties (BL4)
5. Illustrate the different materials and NDT Techniques (BL3)

UNIT-1

Crystallography: Lattice, Crystal structures, Miller indices for planes and directions, Microscopes, microstructures and quantitative metallography, Defects, diffusion.

UNIT-2

Phase Diagrams and Transformations: Phase diagram, equilibrium phase diagram, lever rule, phase transformation

UNIT-3

Fe-C Phase Diagrams: Iron-carbon phase diagram, TTT and CCT curves, and heat treatments.

UNIT-4
Mechanical Behaviour: Introduction to mechanical properties, cold and hot working, strengthening mechanism Fracture, Fatigue and Creep

UNIT-5

Materials: Ceramics and plastic, NDT techniques, alloy designation

text books and references

1. W. D. Callister, Jr., John Wiley and Sons, Materials Science and Engineering an Introduction, 2006.
2. V. Raghavan, Materials Science and Engineering, Prentice Hall of India Pvt. Ltd. 2015
3. S.H. Avener, Introduction to physical Metallurgy, Tata McGraw Hill, 2009

Suggested Readings:

1. E. Dieter, Mechanical Metallurgy, New Age Publications (P) Ltd. 2008
2. S.P. Nayak, Engineering Metallurgy and Material Science, Charoter Publishing house, 2005

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.

H18ME 03/ 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 05/ H20ME 05

MATHEMATICAL MODELING OF MANUFACTURING PROCESSES

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 basic mechanism such as heat and mass transport with associated fluid flow including metallurgical transformation, distortion and residual stress generation in different manufacturing processes. (BL-2)
2. Explain the analysis, numerical simulation at different scale and experimentation for different types of manufacturing processes. (BL-4)
3. Develop the computational models for a manufacturing process relies on mathematical expression of the governing mechanism. (BL-6)
4. Understand the most general to advanced manufacturing processes based on scientific principle. (BL-2)
5. Develop physics based computational model of manufacturing process using standard commercial package. (BL-6)

UNIT – I
Introduction to manufacturing processes, physics of manufacturing processes

UNIT – II
Conventional machining, Non-conventional machining

UNIT - III
Metal forming, welding.

UNIT – IV
Casting and powder metallurgy, Coating and additive manufacturing

UNIT - V
Heat treatment, micro/nano scale manufacturing, Processing of non-metallic materials

Text Books:

1. A Ghosh and A K Mallik, “Manufacturing Science”, East-West Press Pvt Ltd,2nd Ed., 2010.
2. D A Brandt, J C Warner, “Metallurgy Fundamentals”, Goodheart- Willcox, 2009.
3. C Lakshmana Rao and Abhijit P Deshpande, “Modelling of Engineering Materials”, Ane Books Pvt. Ltd., New Delhi, India, 2010.

Suggested Reading:

1. J. Chakrabarty, ‘Theory of plasticity”, 3rd Eds, Elsevier India, 2009.
2. Norman Y Zhou, “Micro joining and Nanoioining”, Woodhead publishing, 2008

H18ME 12/ H20ME 12

MANUFACTURING STRATEGY

Instruction	2	Hours per week
Course Duration	8	Weeks
Credits	2	

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

1. Understand the process of formulation of manufacturing strategy. (BL-2)
2. Apply various tools and techniques for making a world class organization like Toyota production System. (BL-3)
3. Analyze manufacturing functions to gain competitive advantage. (BL-4)
4. Understand the concepts of Total Quality Management and Manufacturing Excellence. (BL-2)
5. Apply Deming's approach to improve Quality in industry. (BL-3)

UNIT-I

Introduction: Manufacturing output, operations systems, operations strategy, functional strategy within context of a firm functional dominance within corporate strategy, concept of world class manufacturing organization, 6 Ps of manufacturing, skinners' view and Hayes and Wheelwright framework of manufacturing strategy, alternative paradigm of manufacturing strategy

UNIT-II

Generic manufacturing strategies: Developing a manufacturing strategy, understanding markets, the concept of order winners and qualifiers, basic characteristics and specific dimensions of order winners and qualifiers, some specific order winners and qualifiers-I,II &III, Some specific order winners and qualifiers (Non operation related criteria.

UNIT-III

Developing an Operations Strategy: Methodology, Roth and Miller classification, enlightened View of manufacturing.

Manufacturing Strategy Taxonomy: Some evidences from China, Quality Management, Manufacturing Excellence, and Total Quality Management

UNIT-IV

Deming's approach to Quality, business Excellence Awards, Process Choice and 3 Dimensional View, Product Profiling, Critical success factors for World Class Manufacturing, Value Added Engineering, Total Employee Involvement, HR theories for Operations Strategy, Flexible Manufacturing system.

UNIT-V

Concept of focus wrt manufacturing strategy, Toyota production System, World Class Manufacturing and India, Achieving World Class Status.

Text Books:

1. John Miltenburg ,"Manufacturing Strategy: How to Formulate and Implement a Winning Plan", Productivity Press, 2017.
2. Danny Samson ,"Manufacturing & Operations Strategy", Prentice Hall publication, 1993.
3. Terry Hill and Alex Hill, **"**Manufacturing Operations Strategy" Palgrave Macmillan publication, 2009

Suggested Readings:

1. Taiichi Ohno,"Evolution Of Toyota Production System", Kindle Edition, 2017.
2. Richard J. Schonberger, "World class Manufacturing", Free Press, 2008

H18ME 33/ H20ME 33

ROBOTICS AND CONTROL: THEORY AND PRACTICE

Instruction	2 hours per week
Course Duration	8 weeks
Credits	2

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

1. Understand the spatial transformations associated with rigidbody motions. **(BL2)**
2. Develop skill in performing kinematics and dynamic analysis of robot systems. **(BL3)**
3. Analyze different robot manipulators **(BL4)**
4. Understand the concept of robot exosleleton **(BL2)**
5. Examine the Robot Assisted Percutaneous Interventions (**BL4)**

Unit 1

Introduction: Coordinate Frames and Homogeneous Transformations-I, Coordinate Frames and Homogeneous Frames-II, Differential Transformations, Transforming Differential Changes between Coordinate Frames

Unit 2

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 3

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 4

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 5

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

Textbooks and references

1. Mittal & Nagrath Robotics and Control, ata 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

FOUNDATION OF COGNITIVE ROBOTICS

Instruction	1 hours per week
Course Duration	4weeks
Credits	1

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

1. Understand importance of cognitive robot and smart materials (BL2)
2. Explain about intelligence, thinking (BL2)
3. Develop knowledge of artificial intelligence related to robots (BL3)
4. Design intelligent systems (BL6)
5. Apply AI based approach to various systems (BL3)

Unit 1

Introduction: Introduction to Cognitive robotics and Human Robot Interaction, Smart materials I, II, III

Unit 2

Intelligence Thinking: Thinking, Cognition, and Intelligence, Defining Intelligence - Embodiment and Its Implications.

Unit 3

Artificial Intelligence and Theory of Intelligence: Role of Neuroscience and Bio robotics, Synthetic Methodology for Intelligence

Unit 4

Intelligent System Design and Cognition Development: Properties of Complete Agents, Agent Design Principle, Developmental Robot Design, Matching brain and Body Dynamics

Unit 5

Control of Intelligent Systems- AI based Approach, Artificial Neural Networks (ANN), Fuzzy Logic, Genetic Algorithms and Other Nature Inspired Methods, Optimal Control using ANN

Textbooks and references

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