M.TECH. IN MANUFACTURING ENGINEERING

Program Structure (Applicable to 2023 admission onwards)

YEAR	FIRST SEMESTER						SECOND SEMESTER					
	SUB CODE	**SUBJECT NAME**	**L**	**T**	**P**	**C**	**SUB CODE**	**SUBJECT NAME**	**L**	**T**	**P**	**C**
I	MIE 5111	Numerical Methods and Computer Programming	3	1	0	4	MIE 5213	Additive Manufacturing Technology	3	1	0	4
	MIE 5116	Manufacturing Materials and Characterisation	3	1	0	4	MIE 5214	Automation In Production and CNC Technology	3	1	0	4
	MIE 5117	Modern Manufacturing Processes and Technology	3	1	0	4	MIE ****	Program Elective-I	3	1	0	4
	MIE 5118	Fluid Power Control and Automation	3	1	0	4	MIE ****	Program Elective-II	3	1	0	4
	MIE 5119	Machining Science and Technology	3	1	0	4	MIE ****	Program Elective-III	3	1	0	4
	MIE 5143	Industrial Automation Lab	0	0	3	1	MIE ****	Open Elective	3	0	0	3
	MIE 5144	Geometric Modelling Lab	0	0	3	1	HUM 5051	Research Methodology and Technical Communication*	1	0	3	2
	MIE 5145	Material Testing and Tribology Lab	0	0	3	1	MIE 5242	Simulation Lab	0	0	3	1
	HUM 5051	Research Methodology and Technical Communication*					MIE 5243	Advanced Manufacturing Engineering Lab	0	0	3	1
	Total					**23**						**27**
	THIRD AND FOURTH SEMESTER											
II	MIE 6091	Project Work and Industrial Training							**0**	**0**	**0**	**25**

*TAUGHT IN BOTH SEMESTERS AND EVALUATED AND CREDITED IN THE SECOND SEMESTER

**LAB COURSES 2 & 3 AND 4&5 MAY BE COMBINED INTO ONE BY EITHER ALLOTTING 6 Hrs/WEEK OR 3 Hrs/WEEK WITH A PROVISION FOR MINI PROJECT/ASSIGMENTS

PROGRAM ELECTIVES		OPEN ELECTIVES	
COURSE CODE	**COURSE TITLE**	**COURSE CODE**	**COURSE TITLE**
	PROGRAM ELECTIVE I	MIE 5301	Design and Analysis of Experiments
MIE 5412	Design of Manufacturing Tools	MIE 5302	Design of Curves and Surfaces
MIE 5413	Finite Element Methods in Manufacturing Engineering	MIE 5303	Energy Storage Systems
MIE 5414	Heat Treatment of Manufacturing Metals and Alloys	MIE 5304	Mechanics of Polymers
MIE 5415	Laser Based Material Processing	MIE 5305	Principles of Lean in Production Systems
MIE 5408	Machine Learning and Its Application to Mechanical Engineering	MIE 5306	Product Design and Development
	PROGRAM ELECTIVE II	MIE 5307	Quality Control and Reliability
MIE 5403	Computational Fluid Dynamics	MIE 5308	Renewable Energy Technology
MIE 5404	Design for Manufacturing		
MIE 5416	Manufacturing of Non-Metallic Products		
MIE 5409	Mechanics of Composite Materials		
MIE 5417	Metal Casting and Joining Technology		
	PROGRAM ELECTIVE III		
MIE 5418	Application of Mechatronics Elements in Automation		
MIE 5419	Computer Integrated Manufacturing Systems		
MIE 5420	Lean Manufacturing		
MIE 5421	Mechanics of Bulk Metal Forming		
MIE 5422	Micro Machining Processes		

FIRST SEMESTER – CORE COURSES

MIE 5111 NUMERICAL METHODS AND COMPUTER PROGRAMMING [3 1 0 4]

Introduction to Computer Programming: Environment, Mathematical Operations, Governing Equations, Approximations and Errors: Round-off Errors, Truncation Errors, Total Numerical Error, Model Errors. Solution to Nonlinear Equations Bracketing and Open methods, Roots in Engineering and Science, Newton-Raphson Method. Differential Equations: Initial and Boundary value problems, Euler's Method, Runge-Kutta Methods. Solution to Linear Algebraic Equations: Gauss elimination, LU factorization, Cholesky factorization, Jacobi Method, Gauss-Seidel method, Relaxation technique, FFT. Curve Fitting and Interpolation: Linear, polynomial and nonlinear Regression, Splines and piecewise interpolation. Numerical Differentiation and Integration: Richardson Extrapolation, Derivatives of unequally spaced data, Partial Derivatives, The trapezoidal rule, Simpson's Rules, Higher-Order Newton-Cotes formulas, Numerical Integration of Functions-Romberg integration, Gauss quadrature. Computer programming using relevant Case Studies.

References:

1. Rao, Singiresu S. *Applied numerical methods for engineers and scientists*. Prentice Hall Professional Technical Reference, 2001.
2. Bradie B., *A Friendly Introduction to Numerical Analysis*, Pearson Prentice Hall, 2006.
3. Ralston A. and Rabinowitz P., A First Course in Numerical Analysis, McGraw Hill, 2001
4. Mathews J. H. and Fink K. D., *Numerical methods using MATLAB*. Pearson Prentice Hall, 1999.
5. Chapra S. C., Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw Hill, 2017.
6. Chapra S. C. and Clough D, Applied Numerical Methods with Python for Engineers and Scientists, McGraw Hill, 2022.

MIE 5116 MANUFACTURING MATERIALS AND CHARACTERISATION [3 1 0 4]

Mechanical Behavior of Materials & Engineering Alloys: Plastic deformation, strengthening mechanisms, damping properties of materials, fatigue & creep mechanisms Ferrous and nonferrous alloys used in engineering applications. Modern Materials and Alloys: Super alloys - Refractory metals - Shape memory alloys - Dual phase steels, Micro alloyed, High strength low alloy steel, Transformation induced plasticity (TRIP) steel. Composite Materials: Metals, ceramics and plastics based composites, processing techniques, types and applications. Advanced Engineering Materials: Metallic glasses, semiconductors, biomaterials as well as smart materials and nanoengineered materials.

Surface Modifications of Materials: Mechanical surface treatment and coating – coatings for improving the mechanical properties of material surfaces. **Characterization of Materials:** Hardness measurements – Conventional and Nano indentation, Optical microscopy, Scanning electron microscopy, Transmission electron microscopy principles, X-Ray diffraction and X-Ray Fluorescence. **Characterization of Surfaces:** Characterization of surface microstructure & properties, Measurement of coating thickness, Measurement of residual stress & stability, FTIR.

References:

1. Thomas H. Courtney, (2000), Mechanical Behavior of Materials, McGraw Hill.
2. Callister W.D. (2013), Material Science and Engineering- An introduction, Wiley – Eastern, 9th Edition.
3. Yinquan Yu, Sam Zhang (2022), Materials in Advance Manufacturing, 1st edition, CRC press.
4. Davis, J.R., (2001), Surface Engineering for corrosion and wear resistance, ASM International.
5. Raghavan, V. (2003), Physical Metallurgy, Prentice Hall of India.
6. Yang Leng (2008), Materials Characterization – Introduction to microscopic and spectroscopic methods, Wiley

MIE 5117 MODERN MANUFACTURING PROCESSES AND TECHNOLOGY [3 1 0 4]

Non-traditional manufacturing processes: AJM, WJM, AWJM and USM working principle, Equipment, Process parameters, Electrical EDM & WEDM - Working principle, Equipment, Process parameters, CHM and ECM, Working principle, Equipment, Process parameters, LBM, PAM, EBM-Working principle, Equipment, Process parameters, Advanced casting processes: Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting. Advanced welding processes: Electron beam welding (EBW), Laser beam welding (LBW), Utra-sonic welding (USW), High energy rate forming (HERF) processes: Electro-magnetic forming, Explosive forming, Electro-hydraulic forming, Stretch forming, and Contour roll forming, Rapid prototyping and rapid manufacturing.

References:

1. Bhattacharya, *New technology*, Institution of Engineers, India.
2. HMT, *Production technology*, Tata McGraw Hill.
3. PS Pandy& H.S Shan, *Modern Machining Process*, Tata McGraw Hill.
4. ASM, *Metals hand book*, Vol-3.
5. F.M Wilson, *High velocity forming of metals*, ASTMW Pretence Hall.

MIE 5118 FLUID POWER CONTROL AND AUTOMATION [3 1 0 4]

Introduction to oil hydraulics and pneumatics, Advantages and limitations, Introduction to Hydraulic systems, Hydraulic actuators and accessories, calculation of force, speed, rotary actuators, accumulator, Hydraulic valves, Construction and working of various types of Direction control valves, Hydraulic circuits. Components of the pneumatic system: Air generation and distribution, Constructional details and working of filter, lubricator, pressure regulator, cylinders, Manual pneumatics, Symbols of pneumatic valves, Design of manually operated circuits, control of multiple actuators, Electro pneumatics, Electrically actuated direction control valves, Relay control systems, Limit switches, pneumatic proximity sensors Design of pneumatic and electro pneumatic circuits.

References:

1. Cundiff John S., and Kocher Michael F., Fluid Power Circuits and Controls, CRC Press, 2019.
2. Esposito Anthony, Fluid Power with Applications, Pearson Education Limited, 2013.
3. Ilango S., and Soundararajan V., Introduction to Hydraulics and Pneumatics, 2nd Ed., 2011.
4. Rabie Galal M., Fluid Power Engineering, McGraw Hill, 2009.
5. Johnson James, Introduction to Fluid Power, Delmar Thomson Learning, 2002.
6. Parr Andrew, Hydraulics and Pneumatics, Butterworth-Heinemann Ltd., 1991.

MIE 5119 MACHINING SCIENCE AND TECHNOLOGY [3 1 0 4]

Cutting tool geometry and nomenclatures, Tool reference systems, Indexable inserts, ISO specification of tool holders and inserts, Cutting Tool Materials, Mechanics of metal cutting, Mechanisms of chip formation – ductile and brittle materials, Determination of shear plane angle, Friction in metal cutting, Ploughing force, Power and energy relationship, High speed machining, Heat sources in metal cutting, Temperature in chip formation, Temperature zones and distribution, Heat transfer in a moving material, Cutting temperature models, Cutting fluids types and functions, Methods of application, Sustainable machining processes, Desirable properties of tool materials, Characteristics of tool materials, types of tool materials, Tool coatings, Mechanisms of tool wear, Modes of tool failure, Types of tool wear, Tool life assessment, Tool life equations, Sustainable machining Economics and cost analysis in machining, Vibration and chatter in machining, Measurement of cutting forces and cutting temperatures.

References:

1. M.C. Shaw, *Metal cutting principles*, Oxford University Press, Second Edition, 2005.
2. G. Boothroyd, and W. A. Knight, *Fundamentals of Metal Machining and Machine Tools*, CRC Press, Third Edition, 2005.
3. D. A. Stephenson, J. S. Agapiou, *Metal Cutting Theory and Practice*, CRC Press, Third Edition, 2016.
4. A. Bhattarcharya, *Metal Cutting-Theory and Practice*, New Central Book Agency Pvt. Ltd., Kolkata, 1984.
5. B.L. Juneja, G. S. Sekhon, *Fundamentals of Metal cutting & Machine Tools*, New Age International (p) Ltd, Second Edition, 2003.
6. V.C. Venkatesh, S. Chandrasekharan, *Metal cutting*, Prentice Hall, 1985.

MIE 5143 INDUSTRIAL AUTOMATION LAB [0 0 3 1]

Pneumatic controls: Pneumatic components and their application circuits.

Electro-pneumatic components, and their application circuits.

Hydraulic controls: Hydraulic and electrohydraulic components and their application circuits.

References:

1. Peter Croser, Frank Ebel, Pneumatics Basic Level TP 101, Festo Didactic GMBH & Co, Germany, 2002.
2. Prede G. and Scholz D., Electro pneumatics Basic Level, Festo Didactic GMBH & Co, Germany, 2002.
3. Hasebrink J.P. and Kobler R., Fundamentals of Pneumatic Control Engineering, Festo Didactic GMBH & Co, Germany, 2002.

MIE 5144 GEOMETRIC MODELLING LAB [0 0 6 2]

Sketcher work bench; Part design work bench; Assembly and drawing; Surface Modeling; Mould and sheet metal designs; Creating the model using CMM data.
Open Ended Experiments - Mini Project work (on Geometric Modelling of complex mechanical components and assemblies)

References:

1. Sham Tickoo, *CATIA – for Engineers and Designers*, Dreamtech Press, New Delhi, 2005.
2. Kirstie Plantenberg, *Introduction to CATIA V5 Release 19*, SDC Publications, 2009.

MIE 5145 MATERIAL TESTING AND TRIBOLOGY LAB [0 0 3 1]

Heat treatment of steel- Annealing and normalizing, Heat treatment of steel- Hardening and Tempering, Specimen preparation for Image Analyzer, Microstructure analysis of above specimen, Tensile test specimen preparation from the above heat treated specimens, Hardness test for above specimens (Brinnel and Rockwell), Wear test, Nondestructive testing, Demonstration on two-high hand operated rolling mill, Analysis using SEM and XRD, use of Autoclave for manufacturing composite material, scratch test.

References:

1. Serope Kalpakjian, Manufacturing Engineering and Technology, Pearson Education Asia, 2000.
2. Donald R. Askeland, Essentials of material science, Thomson India edition, 2007.
3. Sidney H Avner, Introduction to physical metallurgy, Tata Mcgraw hill edition, 1997.

SECOND SEMESTER – CORE COURSES

MIE 5213 ADDITIVE MANUFACTURING TECHNOLOGY [3 1 0 4]

Introduction: Traditional Manufacturing v/s Additive Manufacturing (AM); Computer Aided Design (CAD) and AM; AM Process Chain; Application Level: Direct Processes, Rapid Prototyping, Rapid Tooling, Rapid Manufacturing; Indirect Prototyping and Tooling, Indirect Manufacturing. Generation of Physical Layer Modelling: Tessellation (STL Format) and Tessellation Algorithms. Defects in STL Files and Repairing Algorithms. Different types of STL format software, various Slicing Procedures. Materials for AM: Different Materials used for AM. Use of Multiple Materials, Multi-Functional and Graded Materials in AM. Role of Solidification Rate. Evolution of Non-Equilibrium Structure, Structure Property Relationship. Grain Structure and Micro-Structure. Technologies of AM: Liquid Based-Stereo Lithography and Solid Ground Curing; Powder Based-Selective Laser Sintering and Three Dimensional Printing; Solid Based-Fused Deposition Modelling (FDM) and Laminated Object Manufacturing (LOM) and other technologies as per ASTM F 42, Support Structure in AM, Post Processing Requirements, Defects in AM Processes, Accuracy and Surface Quality in AM, Effect of Part Orientation, Surface Finish, Build Time and Cost, Micro and Nano AM Processes. Rapid Prototyping: Classification and Definition, Strategic Aspects for the Use of Prototypes, Applications of Rapid Prototyping in Industrial Product Development. Rapid Tooling: Classification and Definition of Terms, Properties of Additive Manufactured Tools, Indirect Rapid Tooling Processes: Molding Processes and Followup Processes, Indirect Methods for the Manufacture of Tools for Plastic Components, Indirect Methods for the Manufacture of Metal Components. Rapid Tooling: Tools based on Plastic Rapid Prototyping Models and Methods. Metal Tool Based on Multilevel AM Processes, Direct Tooling, Tools based on Metal RP processes. Rapid manufacturing: Feasibility, Cost estimation, Breakeven analysis, Sustainability Aspects.

References:

1. Ian Gibson, David W. Rosen, Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing Springer, 2010.
2. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers, 2011.
3. J.D. Majumdar and I. Manna, Laserassisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3642- 28359-8.
4. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech, 2012.
5. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.

MIE 5214 AUTOMATION IN PRODUCTION AND CNC TECHNOLOGY [3 1 0 4]

Fundamentals of Manufacturing and Automation Manufacturing support systems, Automation in production systems, Automation principles & strategies, automated systems & Automation functions, Levels of automation, Components of

CNC machines, classification, construction details of CNC machines, machine structure, guideways, spindle, measuring systems, Drives and Controls, CNC Toolings, Interchangeable tooling system, preset and qualified tools, coolant fed tooling system, Modular fixturing, quick change tooling system, Introduction to Robotics Introduction, Robot configuration, Robot motions, Programming the robots, Robot programming languages, End effectors, Work cell, Control and interlock, Robot transformation and sensors, Programmable Logic Controls (PLC) and programming. Application of IoT in automation machines.

References:

1. Radhakrishnan P., *Computer Numerical Control Machines*, New Central Book Agency (P) Ltd., Kolkata, 2004.
2. Groover Mikell P., *Automation, Production Systems, and Computer Integrated Manufacturing*, Prenice Hall of India, New Delhi, 2001.
3. HMT Limited, *Mechatronics*, Tata McGraw Hill publishing company Ltd. New Delhi, 1998.
4. P.N Rao, *CAD/CAM Principles and Applications*, Tata McGraw Hill Company, New Delhi, 2009.
5. Thomas Crandell M., *CNC Machining and Programming, an Introduction*, Industrial Press Inc., New York, 2002.

HUM 5051 RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION [1 0 3 2]

Research Methodology: Basic concepts: Types of research, Significance of research, Research framework. Sources of data, Methods of data collection. Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem. Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, Characteristics and Types of hypothesis, Elements of research design, Introduction to various sampling methods Sources of data, Collection of data, Research reports, references styles, Effective Presentation techniques, Research Ethics.

References:

1. Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. John Wiley &Sons.
2. Zikmund, W. G., Babin, B. J., Carr, J. C., & Griffin, M. (2013). *Business research methods*. Cengage Learning.
3. Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
4. Donald R Cooper & Pamela S Schindler, *Business Research Methods*, McGraw Hill International, 2018.

MIE 5242 SIMULATION LAB [0 0 3 1]

Basics of FEA - ANSYS APDL - Truss and Beam, ANSYS APDL - Plane Stress, Plane Strain, Shell. Workbench - 3D Structural, Fluid Flow, Thermal, and Composite Material, Kinematic Simulation: Casting Simulation - Sand Casting, Die Casting, Forging Simulation Exercises, Open Ended experiments on Forming Simulation.

References:

1. Daryl L. Logan, “First course in Finite Element Method”–Fifth India Edition, Thompson Ltd, India, 2020.
2. Xiaolin Chen, Yijun Liu, "Finite Element Modelling and Simulation using ANSYS Workbench" -CRC Press, United States, 2015.
3. ANSYS User Manual ver 2022 R2
4. Zcast User Manual
5. AFDEX User Manual
6. Online - Virtual Labs on Metal Forming

MIE 5243 ADVANCED MANUFACTURING ENGINEERING LAB [0 0 3 1]

CNC Machines: Exercises on Turning centre and Vertical Machining Centre. Use of different canned cycles. **Non-conventional machining:** Exercises on Electric Discharge Machine (EDM), Wire EDM and Drill EDM, Abrasive Water Jet machine. **Gear Hobbing:** Exercise to prepare blank and cut teeth for helical gears. **Additive Manufacturing:** Exercise on a 3D printer to produce polymer parts using Fused Deposition Modelling technique. **Quality control:** Use of Coordinate Measuring Machine to assess of quality of parts.

References:

1. Smid Peter., CNC programming hand book, Industrial Press Inc., New York, 2000.
2. V. K. Jain, Advanced Machining Processes, Allied Publishers Pvt.Ltd.,New Delhi, 2004
3. Chua Chee Kai; Leong Kah Fai, 3D Printing and Additive Manufacturing, World Scientific, London, 2014

PROGRAM ELECTIVE COURSES

PROGRAM ELECTIVE I

MIE 5412 DESIGN OF MANUFACTURING TOOLS [3 1 0 4]

Design considerations for cutting tools, design of turning tools, chip breakers, parting-off tool, Form tools design. Design of drilling, reaming, tapping and broaching tools, Design of milling cutters, Introduction on presses and press tools, shearing theory, cutting force clearances between punch and die, methods of reducing cutting force, Tonnage calculation and press tool accessories. Die block calculations, strip layout, simple die, compound die and progressive die, Theory of Bending, bend radii, bend allowances, bending methods. Spring back effect, bending dies, Design of deep drawing dies.

References:

1. Donaldson Cyril, Tool Design, Harper, 2002.
2. Arshenov V., Alekseev G, Metal cutting theory and cutting tool design, MIR Publishers, 1970.
3. Wilson Frank R, Fundamentals of tool design, 1964.
4. Ranganath B J, Metal cutting and tool design, Vikas Publishing House Pvt.Ltd., 2004.
5. CMTI Machine, Tool design handbook, Tata McGraw Hill, 2004.

MIE 5413 FINITE ELEMENT METHODS IN MANUFACTURING ENGINEERING [3 1 0 4]

Introduction: General procedure of FEM. Formulation Methods - Direct Method: Spring and truss elements, arbitrarily oriented elements, transformation matrix,plane truss. Energy Method: Principle of total minimum potential energy, Formulation of plane stress/strain elements. Galerkin's Weighted Residual Method: Beam theory, formulation of beam element, arbitrarily oriented beam elements, plane frame. Isoparametric Elements: Formulation of truss, plane and solid elements. Introduction to Analysis Types: Modal or frequency analysis, thermal analysis, thermos-structural analysis, axi-symmetric analysis, fluid flow analysis. Software Practices: Finite element analysis on a software system for finding solution of FEM based problems related to stress-strain analysis. Application of FEM in manufacturing engineering

References:

1. Daryl L Logan, *A First Course in Finite Element Method*, Thomson Asia Pvt. Ltd, Bangalore, 2002.
2. Bathe K J, *Finite Element Procedures*, Prentice Hall of India New Delhi, 2003.
3. Martin H.C. and Carey G.F., *Introduction to Finite Element Analysis*, Tata McGraw Hill, New Delhi, 1975.
4. Segerlind L J., *Applied Finite Element Analysis*, John Wiley, New York, 1984.
5. Cook Robert D, *Concepts and Applications of Finite Element Analysis*, John Wiley and Sons New York, 2000

MIE 5414 HEAT TREATMENT OF MANUFACTURING METALS AND ALLOYS [3 1 0 4]

Heat treatment related phase transformation reactions in iron –iron carbide phase diagram, lever rule application in binary steels and cast iron, alloying elements effect on austenite loop, austenite, ferrite stabilizers, carbide and graphite formers, kinetics, mechanism, influencing parameters on austenite formation, kinetics, mechanism, influencing parameters on isothermal diffusion and shear process controlled austenite transformation into room temperature structures and factors involved in transformation process, continuous cooling transformations. Heat treatment of steels and nonferrous metals involving phase transformation, change in chemical composition, deformation and combination, surface hardening, hardenability and its importance, heat treatment furnaces. Heat treatment and application of commercial steels, tool steels, stainless steels, cast iron, heat treatment and application of grey cast iron, white, malleable, spheroidal cast iron and alloy cast irons, special nonferrous alloys and composites, major heat treatment defects.

References:

1. T.V. Rajan, C P Sharma and Alok Sharma, *Heat treatment principles and techniques*, PHI Publication, Delhi 1999.
2. Vijendra Singh, *Heat Treatment of Metals*, Standard Publishers Distributors, Delhi, 1998.
3. ASM Handbook – Heat treating, Vol 4.
4. ASM Handbook – Alloy phase diagram (500s), Vol 3.
5. Romesh C Sharma, Principles of Heat Treatment of Steels, New Age International (P) Limited, New Delhi, 1996.

MIE 5415 LASER BASED MATERIAL PROCESSING [3 1 0 4]

Basic principles of lasers, Types of lasers, Laser optics and generation, Applications of lasers, Laser for material processing, Forms of laser cutting,

Components of laser cutting system, Laser cutting principles, Laser engraving, Forms of laser drilling, Laser welding process, Effect of beam characteristics, Joint configuration, Weldment discontinuities, Laser forming process, Principle of laser forming, Laser forming mechanisms, Laser surface heat treatment, Process parameters, Surface integrity of treated surface, Laser surface melting, Laser direct metal deposition, Laser cladding, Laser physical vapor deposition, Laser shock peening, Dangers in laser handling, Standards and safety limits, Risks/hazards and its mitigation.

References:

1. William M. Steen &Jyotirmoy Mazumder, Laser Material Processing, Springer, 2010.
2. John C. Ion, Laser Processing of Engineering Materials: Principles, Procedure and Industrial Application. Elsevier, 2005.
3. Elijah Kannatey-Asibu, Jr., Principles of Laser Materials Processing, Wiley, 2009.
4. Ian Gibson, David W. Rosen and Brent Stucker, Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer, 2015

MIE 5408 MACHINE LEARNING AND ITS APPLICATION TO MECHANICAL ENGINEERING [3 1 0 4]

Introduction to Computer Programming: Environment, Mathematical Operations, Governing Equations, Approximations and Errors: Round-off Errors, Truncation Errors, Total Numerical Error, Model Errors. Solution to Nonlinear EquationsBracketing and Open methods, Roots in Engineering and Science, Newton-Raphson Method. Differential Equations: Initial and Boundary value problems, Euler's Method, Runge-Kutta Methods. Solution to Linear Algebraic Equations: Gauss elimination, LU factorization, Cholesky factorization, Jacobi Method, Gauss-Seidel method, Relaxation technique, FFT. Curve Fitting and Interpolation: Linear, polynomial and nonlinear Regression, Splines and piecewise interpolation. Numerical Differentiation and Integration: Richardson
Extrapolation, Derivatives of unequally spaced data, Partial Derivatives, The trapezoidal rule, Simpson's Rules, Higher-Order Newton-Cotes formulas, Numerical Integration of Functions-Romberg integration, Gauss quadrature. Computer programming using relevant Case Studies.

References:

1. Rao, Singiresu S. Applied numerical methods for engineers and scientists. Prentice Hall Professional Technical Reference, 2001.
2. Bradie B., A Friendly Introduction to Numerical Analysis, Pearson Prentice Hall, 2006.
3. Ralston A. and Rabinowitz P., A First Course in Numerical Analysis, McGraw Hill, 2001
4. Mathews J. H. and Fink K. D., Numerical methods using MATLAB. Pearson Prentice Hall, 1999.
5. Chapra S. C., Applied Numerical Methods with MATLAB for Engineers and Scientists, McGraw Hill, 2017.
6. Chapra S. C. and Clough D, Applied Numerical Methods with Python for Engineers and Scientists, McGraw Hill, 2022.

PROGRAM ELECTIVE II

MIE 5403 COMPUTATIONAL FLUID DYNAMICS [3 1 0 4]

Models of Flow and derivation of governing conservation differential equations for different models for conservation of mass, momentum and energy. Discussion of characteristics and boundary and initial conditions. Basic numerical methods to solve first diffusion related flow physics followed by convective dominated diffusion flows. Difficulties and strategies to solve such flows.
Algorithmic approach and convergence as well as stability. Turbulence and related closure using turbulence modelling.

References:

1. John D Anderson Jr, Computational Fluid Dynamics- The Basics with Applications. International Edition. McGraw Hill. New York, 1995.
2. Suhas V Patankar, Numerical Heat Transfer and Fluid Flow. Hemisphere / McGraw Hill. New York, 1980.
3. H.K. Versteeg and W. Malalasekera, An Introduction to Computational Fluid Dynamics-The Finite Volume Method. Longman Scientific & Technical. England, 1995.
4. K.Muralidhar and T.Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 2003.
5. Tennekes H. and Lumley J.L., A First Course in Turbulence, The MIT press, 1972.

MIE 5404 DESIGN FOR MANUFACTURING [3 1 0 4]

Significance of design for manufacturing (DFM), factors influencing design, selection of materials and manufacturing processes. Design for assembly,

serviceability and environment. DFM of formed metal components, castings, machined components and non-metallic parts. Process engineering designing for heat treatment, sequence of operations for manufacturing of components. Manufacturing drawings-dimensioning for manufacturing, fits, tolerance and surface finish consideration in design, preparation of manufacturing drawings of components.

References:

1. Geoffrey Boothroyd, Peter Dewhurst and Winston A. Knight, Product Design for Manufacture and Assembly, (3e), CRC Press, 2011.
2. James G. Brala, Design for Manufacturability Handbook, (2e), McGraw Hill, New York, 1999.
3. Kevin Otto and Kristin Wood, Product Design, Pearson Education, Delhi, 2001.
4. Corrado Poli, Design for Manufacturing: A Structured Approach, Butterworth-Heinemann Ltd., 2001

MIE 5416 MANUFACTURING OF NON-METALLIC PRODUCTS [3 1 0 4]

Introduction to Non-Metallic Materials: Classification, Polymers: Classification of Polymers, Machining of Polymers, Rubbers: Properties and Applications of Rubber, Rubber Forming Processes, Glass: Types of Glasses, Processing and Manufacturing Techniques of Glass Vessels: Ceramics: Processing of Ceramics, Casting: Slip Casting, Tap Casting, Plastic Forming: Mounted Abrasive Machining, Free Abrasive Machining, Impact Abrasive Machining, Composites: Classification and Properties of Composites, Properties and Secondary Processing Techniques, Rapid Prototyping (RP) in Manufacturing of Non-Metallic Products; Different RP Processes and Equipment used in Manufacturing of Non-Metallic Components.

References:

1. Polymer Science and Technology-Plastics, Rubber, Blends and Composites by Ghosh, TMH.
2. Rubber Processing Technology, Materials and Principles by J.L. White, Hanser Publishers.
3. Glass Engineering Handbook by E. B. Shand, McGraw-Hill.
4. Introduction to Ceramics by Kingery Bowen and Uhlmann, John Wiley & Sons publishers.
5. Handbook of Composites by George Lubin, Springer.

MIE 5409 MECHANICS OF COMPOSITE MATERIALS [3 1 0 4]

Importance of composite materials, overview, significance and characteristics of composite material, applications and developments, types and classification, Manufacturing of different types of composite materials, quality inspection methods, micro and macro mechanics of fiber reinforced lamina and macro mechanics of composite laminate, testing of composite materials, analysis of laminated composite beams, damage prediction, theories of failures for composite materials.

References:

1. Mallick. P.K., Fiber Reinforced Composites: Materials, Manufacturing and Design (3e), CRC Press, 2007
2. B. D. Agarwal, L.J. Broutman, K. Chandrashekhara, Analysis and performance of fiber composites, Wiely, 2012
3. Robert M. Jones, Mechanics of Composite Materials (2e), Taylor & Francis, 2015
4. Michael W. Hyer, Stress analysis of fiber Reinforced Composite Materials, McGraw Hill Publication, 2014.

MIE 5417 METAL CASTING AND JOINING TECHNOLOGY [3 1 0 4]

Casting: Patterns, pattern allowances, mould and core making, melting practice and furnaces, cooling and solidification, Elements and design of gating system and risers, application of chills. Different moulding and casting processes, Casting defects, Fettling and testing of casting. Welding and Allied Processes: Classification, structure and characteristics of welding arc, arc welding power sources, duty cycle, metal transfer, Selection of Welding process. Different welding processes: Shielded Metal Arc Welding (SMAW), Submerged Arc Welding (SAW), Gas Tungsten Arc Welding (GTAW/TIG), Gas Metal Arc Welding (GMAW), Electro-slag and Electro-gas welding, Resistance welding, Solid-state welding processes, Diffusion welding, Ultrasonic welding, Electron beam welding, Laser welding, Plasma arc welding, Thermit welding, Weld defects, Brazing and Soldering. Welding Metallurgy: Heat flow in welding, Metallurgical transformation in and around weldment, Implication of cooling rates, Heat affected zone (HAZ), Weldability of steels, Design of weldments, Destructive and Non-destructive tests of welding joints.

References:

1. H.S. Bawa, Manufacturing Technology-I, TMH Publications, New Delhi, 2007.

2. S.V. Nadkarni, Modern Arc Welding Technology, Oxford and IBH Publishing Co. Pvt. Ltd., 2010.
3. SeropeKalpakjian and Steven R. Schmid, Manufacturing Processes for Engineering Materials, 4th edition, Pearson Education, 2007.
4. P. L. Jain, Principles of Foundry Technology, 5th edition, 2009.
5. R. S. Parmar, Welding Processes and Technology, 3rd Edition, New Delhi, 2011.

PROGRAM ELECTIVE III

MIE 5418 APPLICATION OF MECHATRONICS ELEMENTS IN AUTOMATION [3 1 0 4]

Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach. Review of fundamentals of electronics: Sensors and Transducers, Drives and Actuators. Signal Processing Data Acquisition and Data Transmission, Data Presentation System. Controllers and Algorithms: Controllers and algorithms used in Mechatronics Systems, Microprocessors controllers and PLCs. Hydraulic systems and their application. Different types of Controls in Mechatronic Systems, Description of PID controllers. Smart materials and their application for sensing and actuation, Mechatronics aspects. Application of software in Mechatronics: Advanced application in Mechatronics. Sensors for conditioning Monitoring, Mechatronic Control in Automated Manufacturing, Micro sensors in Mechatronics. Mechatronic Control in Automated

References:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. G.W. Kurtz, J.K. Schueller, P.W. Claar . II, Machine design for mobile and industrial applications, SAE, publication.
3. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall.
4. R.Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition, 2005
5. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning, 2012
6. John G. Webster, Editor-in-chief, "Measurement, Instrumentation, and Sensors Handbook", CRC Press (1999)
7. Bolton, "Mechatronics – Electronic control systems in mechanical and electrical engineering, 2 nd edition, Addison Wesley Longman Ltd., 2009

MIE 5419 COMPUTER INTEGRATED MANUFACTURING SYSTEMS [3 1 0 4]

Introduction, product life cycle management, group technology, computer aided process planning, artificial intelligence in process planning, production control function, CAD-CAM integration, business planning and forecasting, capacity planning, materials requirement planning, cellular manufacturing, introduction of lean manufacturing techniques and methods, computer aided quality control, integration of quality control with CAD/CAM, computer integrated manufacturing systems, material handling systems, flexible manufacturing systems, adaptive control systems.

References:

1. Mikell P. Groover, Automation, Production Systems, and Computer Aided Manufacturing, 2/e., Prentice Hall, 2001.
2. Dr.Sadhu Singh, Computer Aided Design and Manufacturing, Khanna publishers,2011.
3. Mikell P. Groover, and Zimmers, CAD/CAM: Principles and Applications, 3/e, Tata-McGraw hill, 2010.
4. M.M.M. Sarcar, K. Mallikarjuna Rao, K. Lalit Narayan, Computer Aided Design and Manufacturing, 2/e, Prentice Hall of India, 2008.
5. Yoram Koren, Computer Control of Manufacturing Systems, McGraw Hill Book Company.

MIE 5420 LEAN MANUFACTURING [3 1 0 4]

The lean production system, lean revolution in Toyota, basic elements of lean manufacturing, principles and characteristics of lean manufacturing, MUDA and types, lean manufacturing tools and techniques,cellular manufacturing, Continuous improvement, Just-In-Time, production smoothing, standardized work and KAIZEN, Standardization of operations, Multi-function workers and job rotation, Improvement activities to reduce workforce and increase worker morale foundation for improvements, Shortening of production lead times, Visual Management and Case studies.

References:

1. Monden Y., Toyota Production System: An Integrated Approach to Just-In-Time, (4e), CRC Press, U.S.A, 2011.
2. Rother and Shook, Learning to See: Value Stream Mapping to add Value and Eliminate Muda, The Lean Enterprise Institute, U.S.A., 1999.
3. Gross and McInnis, Kanban Made Simple: Demystifying and Applying Toyota's

Legendary Manufacturing Process, AMACOM Books, U.S.A., 2003.
4. Fled W., Lean Manufacturing: Tools, Techni ques and How to Use Them, CRC Press, U.S.A., 2001.
5. Dailey K. W., The Lean Manufacturing Pocket Handbook, D.W. Publishing Co., 2003.

MIE 5421 MECHANICS OF BULK METAL FORMING [3 1 0 4]

Mechanical behavior of crystalline materials, Mechanics of plastic deformation, Stress in twodimension and three-dimension, Hydrostatic and deviator components of stress, Stress-strain analysis, Yield criteria and flow stress, Workability of the material, Analysis of forming Classifications of metal forming processes, Mechanics of metal forging, Forging analysis, Forging defects, Rolling classification, Rolling equipment, Rolling theories and analysis, Rolling defects, Rolling torque and power, Extrusion classification, Extrusion analysis, Extrusion types, Defects in extrusion, Rod and wire drawing, Analysis of wire drawing, Tube drawing processes and its analysis, Residual stress in metal forming processes.

References:

1. William Hosford & Robert Caddel, *Metal Forming Mechanics & Metallurgy*, Cambridge University Press, UK, 2007.
2. George E. Dieter, *Mechanical Metallurgy*, McGraw Hill Education, India, 2013.
3. B. L. Juneja, *Fundamentals of Metal Forming Processes*, New Age International, India, 2010.
4. R. Narayanasamy, *Metal Working Technology*, Prentice Hall, India, 1997.
5. Surender Kumar, Technology of Metal Forming Processes, Prentice-Hall, India, 2008.

MIE 5422 MICRO MACHINING PROCESSES [3 1 0 4]

Introduction to Micromachining**,** Need, Classification and Applications of micro machining, types of micro Machines, Micro machining cutting tools, Sensors and actuators. Traditional micro machining processes like Micro turning, drilling, milling and grinding, material issues. Abrasive jet micro machining, Abrasive water jet micro machining, Ultrasonic micro machining, Abrasive flow nano-finishing, Magneto rheological finishing. Electric discharge micro machining, Wire electric discharge micro machining, Electric discharge grinding, Electric discharge diamond grinding, Laser beam micro machining, Electron beam micro machining, Ion beam micro machining. Chemical Micro machining, Electro chemical micro machining, Electro chemical micro grinding, Electro stream micro drilling, Electro chemical micro deburring, Shaped tube electrolytic micro machining. Bulk micro machining and its applications, Surface micro machining and its applications.Stiction and antistiction in micro machining. Hybrid micro machining like Wafer bonding, Anodic bonding, Fusion bonding and their applications.

References:

1. V. K. Jain, *Micro Manufacturing Processes*, CRC Press, Taylor & Francis Group, 2012.
2. K. Cheng and D. Huo, *Micro-cutting: Fundamentals and Applications*, John Wiley & Sons, 2013.
3. V.K. Jain, *Advanced Machining Processes*, Allied Publishers Pvt. Ltd., 2007.
4. P. K. Mishra, *Nonconventional Machining*, Narosa Publishing House Pvt. Ltd, 2007.
5. J. A. McGeough, *Advanced Methods of Machining*, Springer, 2011.
6. Y. Qin, *Micro-manufacturing Engineering and Technology*, William Andrew, 2015.
7. J. P. Davim and M. J. Jackson, *Nano and Micromachining*, John Wiley & Sons, 2013.
8. Gad-el-Hak M., *The MEMS Handbook*, Taylor and Francis, 2005.
9. Kahrizi M., *Micromachining Techniques for Fabrication of Micro and Nano Structures*, Intech Open, 2012.

OPEN ELECTIVE

MIE 5301 DESIGN AND ANALYSIS OF EXPERIMENTS [3 0 0 3]

Understanding basic experimental design principles, Working in simple comparative experimental contexts, introduction to R language and its applications in DOE problems, Working with single factors or one-way ANOVA in completely randomized experimental design contexts, Implementing randomized blocks, Latin square designs and extensions of these, Understanding factorial design contexts, Working with two level, 2*k*, designs, Implementing confounding and blocking in 2*k* designs, Working with 2-level fractional factorial designs, Working with 3-level and mixed-level factorials and fractional factorial designs, Simple linear regression models, Understanding and implementing response surface methodologies, Understanding robust parameter designs, Working with random and mixed effects models, Design of computer experiments and the applications in industrial engineering problems.

References:
1. Montgomery, D. C. (2001), Design and Analysis of Experiments, John Wiley & Sons. Inc. ISBN: 0-471-31649-0.
2. Dean, A. M. and Voss, D. T. (1999), Design and Analysis of Experiments (Springer text in Statistics), Springer Science + Business Media, Inc. ISBN: 0-387-98561-1.
3. Box, G. E. P., Hunter, W. G., and Hunter, J. S. (1978), Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building, John Wiley & Sons. Inc. ISBN: 0-471-09315-7.
4. Diamond, W. J. (2001), Practical Experiment Designs for Engineers and Scientists, John Wiley & Sons. Inc. ISBN: 0-471-39054-2.
5. Jeff Wu, C. E. and Hamada, M. I. (2000), Experiments: Planning, Analysis, and Parameter Design Optimization, John Wiley & Sons. Inc. ISBN: 0-471-39054-2.

MIE 5302 DESIGN OF CURVES AND SURFACES [3 0 0 3]

Hardware and software for Computer Aided Design (CAD), geometric modelling concepts of CAD; parametric representation of analytic curves (line, circle, ellipse and hyperbola), synthetic curves (Hermite cubic splines, Bezier curves, B-spline curves, NURBS), analytical surfaces (plane, ruled, tabulated, revolved), synthetic surfaces (Bi-cubic, Bezier, B-spline, NURBS, Coons, Ferguson's and Bi-linear surface patches); 3D transformation (translation, scaling, rotation and concatenation) of geometric entities and their projections.

References:
1. Michael E. Mortenson, Geometric Modeling, Wiley Computer Publishing, John Wiley and Sons, Inc. Second Edition), 1996.
2. Ibrahim K.Zeid, CAD/CAM Theory and Practice, Tata McGraw Hill, New Delhi, 1998.
3. David F. Rogers and J Alan Adams, Mathematical Elements for Compter Graphics, Tata McGraw Hill, New Delhi, 2002.
4. David F. Rogers and J Alan Adams, Procedural Elements for Computer Graphics, McGraw Hill, New York, 2001.
5. Donald Hearn and M Pauline Baker, Computer Graphics, Prentice Hall of India, New Delhi,

MIE 5303 ENERGY STORAGE SYSTEMS [3 0 0 3]

Introduction: Need for energy storage, Different modes of energy storage. Potential energy: Pumped hydro storage, Kinetic energy and compressed gas system, Flywheel storage, Compressed air energy storage, Electrical and magnetic energy storage, Capacitors, Electromagnets, Chemical energy storage, Thermo-chemical, photo-chemical, biochemical, electro-chemical, fossil fuels and synthetic fuels, Hydrogen for energy storage, Solar ponds for energy storage. Electrochemical, Magnetic and Electric Energy Storage Systems: Batteries, Primary, Secondary, Lithium, Solid-state and molten solvent batteries, Lead acid batteries, Nickel Cadmium Batteries, Advanced batteries, Superconducting Magnet Energy Storage (SMES) systems, Capacitor and Batteries, Comparison and application, Super capacitor, Electrochemical Double Layer Capacitor (EDLC. Sensible and Latent Heat Storage: SHS mediums, Stratified storage systems, Rock-bed storage systems, Thermal storage in buildings, Earth storage, Energy storage in aquifers, Heat storage in SHS systems, Aquifers storage, Phase Change Materials (PCMs), Selection criteria of PCMs, Solar thermal LHTES systems, Energy conservation through LHTES systems, LHTES systems in refrigeration and air-conditioning systems, Numerical heat transfer in melting and freezing process. Application of Energy Storage: Food preservation, Waste heat recovery, Solar energy storage, Green house heating, Power plant applications, Drying and heating for process industries.

References:
1. Johannes Jensen Bent Squrensen, *Fundamentals of Energy Storage*, John Wiley, NY , 1984.
2. *IEE Energy Series*, Electro-chemical Power Sources.
3. Baader, W., Dohne, E., Brenndorfer, *Bio-gas in Theory and Practice*.
4. P.D.Dunn, *Renewable Energies*. Peter Peregrinus Ltd, London, United Kingdom, First Edition, 1986.
5. Ibrahim Dincer, *Thermal Energy Storage: Systems and Applications*, Wiley Publications, 2010.

MIE 5304 MECHANICS OF POLYMERS [3 0 0 3]

Introduction, Overview of Polymeric Materials, Polymerization and Crosslinking, Crystallinity, Glass Transition Temperature, Molecular Orientation; Processing of polymers -Thermoplastics and thermosets processing techniques; Kinetic Theory of Rubber Elasticity, Linear elastic relations for rubber elasticity, Mechanics of Elastomers, thermomechanical behavior of polymers; Viscoelasticity - Linear and fractional order models, Maxwell Models,Creep, Stress Relaxation, Dynamic

Response; Mechanical response during plastic deformation and fracture -Yielding and Crazing,viscoplasticity, Linear Fracture Mechanics, Elastic-plastic Fracture, Brittle Fracture, Toughening.Failure mechanisms in polymer matrix composites.

References:

1. R.J. Young and P.A. Lovell, Introduction to Polymers: 3rd Edition, CRC Press, 2011
2. I.M. Ward, J. Sweeney, Mechanical Properties of Solid Polymers, 3rd ed. Wiley
3. R.S. Dave, A.C. Loos, Processing of Composites, Hanser, 2000.
4. Jorgen S Bergstrom, Mechanics of solid polymers: theory and computational modelling, Elsevier, 2015.

MIE 5305 PRINCIPLES OF LEAN IN PRODUCTION SYSTEMS [3 0 0 3]

Introduction: Evolution of Mass production – Traditional vs. Mass production – Evolution of Toyota Production System (TPS) – Business Dynamics of Lean production – Principles of Lean production: Value, Value Stream, Flow, Pull, Perfection.TPS – Tools & Techniques - 1: 3Ms: Muda, Mura, Muri – 7 Wastes in Manufacturing – Lean Tools to eliminate Muda – 5S –, Plan-DoCheck-Act (PDCA), Standardised work, TPM – SMED – Jidoka – Poka Yoke – JIT – Heijunka – Kanban – One piece production, Kaizen, Visual Management, Production smoothing,Shortening production lead time, Shortening setup time – concepts and techniques

References:

1. Monden Y., Toyota Production System: An Integrated Approach to Just-In-Time, (4e), CRC Press, U.S.A, 2011.
2. Rother and Shook, Learning to See: Value Stream Mapping to add Value and Eliminate Muda, The Lean Enterprise Institute, U.S.A., 1999.
3. Gross and McInnis, Kanban Made Simple: Demystifying and Applying Toyota's Legendary
4. Manufacturing Process, AMACOM Books, U.S.A., 2003.
5. Fled W.,Lean Manufacturing: Tools, Techniques and How to Use Them, CRC Press, U.S.A., 2001.
6. Dailey K. W., The Lean Manufacturing Pocket Handbook, D.W. Publishing Co., 2003.

MIE 5306 PRODUCT DESIGN AND DEVELOPMENT [3 0 0 3]

Introduction: Characteristics, design, cost, duration and challenges of successful design and development of products. Development Processes and Organizations: A generic development process and concept of development process, the AMF development process, product development organizations, the AMF organization. Product Planning: The product planning process, Evaluate and prioritize projects, allocate resources and plan timing, complete pre project planning. Identifying Customer Needs: Gather raw data, interpret raw data, organize the needs into a hierarchy, establish the relative importance of the needs and reflect on the results and the process. Product Specifications: What are specifications, establishing target specifications, setting the final specifications. Concept Generation: The activity of concept generation,search externally and internally, explore systematically, reflect on the results and the process. Concept Selection: concept screening, and concept scoring, Concept Testing: Define the purpose of concept test, choose a survey population, survey format, communicate the concept, measure customer response, interpret the result, reflect on the results and the process. Product Architecture: Product architecture, implications of the architecture, establishing the architecture, variety and supply chain considerations, platform planning, related system level design issues. Industrial design: need and impact of industrial design, industrial design process, managing the industrial design process, assessing the quality of industrial design. Design for Manufacturing: Definition, estimation of manufacturing cost, reducing the cost of components, assembly, supporting production, impact of DFM on other factors. Prototyping: Prototyping basics, principles of prototyping, technologies, planning for prototypes. Product Development Economics: Elements of economic analysis, base case financial mode,. Sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

Reference Books:

1. Karl.T.Ulrich, Steven D Eppinger - Product Design and Development - Irwin McGrawHill - 2000.
2. A C Chitale and R C Gupta, Product Design and Manufacturing - PH1, - 3rd Edition, 2003.
3. Timjones. Butterworth Heinmann -New Product Development -Oxford. UCI -1997
4. George E Deiter, Engineering Design, 5th Edition, McGraw-Hill , 2012 .
5. Boothroyd G, Dewhurst P and Knight W, Product Design for Manufacture and Assembly, 2nd Edition, Marcel Dekker, New York, 2002.

6. G Altshuller, H Altov, Lev Shulyak, And Suddenly the Inventor Appeared: TRIZ, The theory of Inventive Problem Solving, Technical Innovation Centre, 2nd Edition, May 1996.
7. Vladimir Petrov, Theory of Inventive Problem Solving, Level 1, Springer Series, 2019, ISBN: 978-3-030-04253-0.

MIE 5307 QUALITY CONTROL AND RELIABILITY [3 0 0 3]

Definitions of the term quality, Inspection and quality control, Causes of variation, Patterns of variation, Frequency distribution, Measures of central tendency and dispersion, The Normal distribution curve, Inequality theorems, Shewhart's bowl drawing experiments, Control charts for variables ($\bar{X}$, R and s charts), Type I and Type II Errors, Process capability analysis, Process capability indexes, Control charts for attributes (p, np, c and u charts), Importance of Acceptance sampling, Single and Double sampling plans, Operating characteristic curve, Acceptable quality level, Lot tolerance percent defective, Average outgoing quality, Average total inspection, Average fraction inspected, Producers risk, Consumers risk, Introduction to life testing and reliability, Equipment failure pattern, Failure rate, Mean Time Between Failure (MTBF), Mean Time To Failure (MTTF), Product rule, Parallel connection, System reliability.

References:

1. Grant E. L and Levenworth R., Statistical Quality Control, McGraw Hill Publications, New York, 2005.
2. Mahajan M.S., Statistical Quality Control, Dhanpat Rai and Co. Pvt. Ltd., Delhi, 2012.
3. Montgomery D.C., Introduction to Statistical Quality Control, John Wieley and Sons, New York, 2005.
4. Juran J.M. and Gryna F.M., Quality Planning and Analysis, Tata McGraw Hill Publications, Delhi, 1995.
5. Bertrand L. Hansen, Quality Control- Theory and Applications, Prentice Hall India, Delhi, 1987.

MIE 5308 RENEWABLE ENERGY TECHNOLOGY [3 0 0 3]

Solar energy –Production and transfer of solar energy – Sun-Earth angles –Availability and limitations of solar energy – Measuring techniques and estimation of solar radiation. Applications of Solar energy, Energy from biomass – Sources of biomass – Different species – Conversion of biomass into fuels, Aerobic and anaerobic bioconversion – Properties of biomass, Biogas plants– Design and operation, Wind energy – Principles of wind energy conversion – Site selection considerations –Wind power plant design – Types of wind power conversion systems – Operation, maintenance and economics, fuel cells, fuel cell power plant, Geothermal fields- Hot dry rock, Energy conversion technologies, Ocean thermal energy conversion, Wave and tidal energy: Scope and economics – Introduction to integrated energy systems.

References:

6. J.A. Duffie and W.A. Beckman: *Solar Energy Thermal Processes*, J. Wiley, 1994.
7. A.A.M. Saigh (Ed): *Solar Energy Engineering*, Academic Press, 1977
8. F. Kreith and J.F. Kreider: *Principles of Solar Engineering*, McGraw Hill, 1978
9. G.N. Tiwari: *Solar Energy-Fundamentals, Design, Modelling and Applications*, Narosa Publishers, 2002
10. H.P. Garg, S.C. Mullick and A.K. Bhargava: *Solar Thermal Energy Storage*, 1985
11. K.M. Mittal: *Non-conventional Energy Systems-Principles, Progress and Prospects*, Wheeler Publications, 1997.

THIRD AND FOURTH SEMESTER

MIE 6091: PROJECT WORK & INDUSTRIAL TRAINING [0 0 0 25]

Students are required to undertake innovative and research-oriented projects, which not only reflect their knowledge gained in the previous two semesters but also reflects additional knowledge gained from their own effort. The project work can be carried out in the institution / industry /research laboratory or any other competent institutions. The duration of project work should be a minimum of 36 weeks. There will be a mid-term evaluation of the project work done after about 18 weeks. An interim project report is to be submitted to the department during the mid- term evaluation. After completing the project work, each student has to submit a project report in prescribed format, to the department / institution. The final project evaluation and viva-voice will be conducted only after submission of the report approved by both internal and external guides. Each student has to make a presentation on the project work carried out, before the departmental M.Tech. project evaluation panel for the project evaluation. The mid-term & end semester project evaluation will be done by the departmental project evaluation panel including the internal as well as external guides.

The students carrying out their project work within the institution need to mandatorily undergo an industrial training for a minimum period of 4 weeks. For the students carrying out their project work in an industry/research laboratory/organization, industrial training is not mandatory.