**DEPARTMENT OF MECHANICAL & MANUFACTURING ENGINEERING, MIT Manipal**

# M.Tech. MANUFACTURING ENGINEERING

Program Structure (Applicable to 2019 admission onwards)

| Year | FIRST SEMESTER | | | | | | SECOND SEMESTER | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **C** | **Sub Code** | **Subject Name** | **L** | **T** | **P** | **C** |
| I | MAT 5155 | Applied Numerical Methods | 3 | 1 | 0 | 4 | MME 5275 | Design of Manufacturing Tools | 3 | 1 | 0 | 4 |
| | HUM 5151 | Research Methodology and Technical Communication | 1 | 0 | 3 | 2 | MME 5276 | Production Automation | 3 | 1 | 0 | 4 |
| | MME 5175 | Advanced Manufacturing Technology | 3 | 1 | 0 | 4 | MME **** | Elective I | 3 | 1 | 0 | 4 |
| | MME 5172 | Advanced Materials and Characterization | 3 | 1 | 0 | 4 | MME **** | Elective II | 3 | 1 | 0 | 4 |
| | MME 5173 | Fluid Power Automation | 3 | 1 | 0 | 4 | MME **** | Elective III | 3 | 1 | 0 | 4 |
| | MME 5174 | Theory of Metal Cutting | 3 | 1 | 0 | 4 | *** **** | Open Elective | 3 | 0 | 0 | 3 |
| | MME 5169 | Advanced Material Testing Lab | 0 | 0 | 3 | 1 | MME 5284 | Finite Element Analysis Lab | 0 | 0 | 3 | 1 |
| | MME 5170 | Geometric Modelling Lab | 0 | 0 | 6 | 2 | MME 5263 | Industrial Automation Lab | 0 | 0 | 3 | 1 |
| | | **Total** | **16** | **5** | **12** | **25** | | **Total** | **18** | **5** | **6** | **25** |
| II | THIRD AND FOURTH SEMESTER | | | | | | | | | | | |
| | MME 6098 | Project Work | | | | | | | 0 | 0 | 0 | 25 |
| | | | | | | | | **Total** | 0 | 0 | 0 | **25** |

| PROGRAM ELECTIVES | | | |
|---|---|---|---|
| MME 5004 | Computational Fluid Dynamics | MME 5012 | Advanced Heat Treatment |
| MME 5005 | Finite Element Methods | MME 5013 | Design for Manufacturing |
| MME 5010 | Additive Manufacturing | MME 5014 | Fracture Mechanics |
| MME 5011 | Advanced Metal Casting and Joining | MME 5015 | Mechanics of Composite Materials |

| OPEN ELECTIVES | | | |
|---|---|---|---|
| MME 5053 | Corrosion Science | MME 5057 | Industrial Safety Engineering |
| MME 5054 | Creativity for Product Design | MME 5058 | Lean Manufacturing |
| MME 5055 | Design of Experiments | MME 5059 | Renewable Energy Technology |

## SEMESTER I

### MAT 5155 APPLIED NUMERICAL METHODS [3 1 0 4]

Finite differences, Netwon-Gregory and Lagrange's interpolation formulae, Inverse interpolation, Newton divided difference interpolation formula. Numerical differentiation and integration-Newton's Cote's quadrature formula, Errors in quadrature formulae. Solution of linear and nonlinear system of equations: Direct methods, Indirect Methods (Iterative methods). Numerical solution of ordinary differential equations. Multi step methods: Adam Bashforth's predictor corrector method, Milne's predictor and corrector method. Boundary value problems: Finite difference method, Numerical solution of partial differential equations, Elliptic partial differential equations : Laplace equation, Poisson equation, explicit finite difference method, Derivative boundary condition, Iterative method, ADI method, Parabolic partial differential equations: Non dimensional form of heat equation, Explicit finite difference scheme, Hyperbolic partial differential equations: Method of Characteristics, Solution of hyperbolic equation by characteristics, Finite difference methods and explicit finite difference method, implicit method, Finite element methods.

**References:**


1. Atkinson K.E, An Introduction to Numerical Analysis, (3e), John Wiley and Sons, 1989.
2. Carnahan, Luther and Wikes, Applied Numerical Methods, New Edition, TMH, 1969.
3. Hilderband F.B, Introduction to Numerical Analysis, (5e), Tata McGraw Hill, New Delhi.
4. Conte S.D and Be Door, Introduction to Numerical analysis, McGraw Hill.
5. Gerald C.F. and Patrick D. Wheatley, Applied Numerical Analysis, (3e), Addison Wesley, 1984.


### HUM 5151 RESEARCH METHODOLOGY AND TECHNICAL COMMUNICATION [1 0 3 2]

Mechanics of Research Methodology: Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation. 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, need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing, Sampling methods- Introduction to various sampling methods and their applications. Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis. Thesis Writing and Journal Publication: thesis writing, journal and conference papers writing, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

**References:**


1. Ranjit Kumar, Research Methodology- A Step-By-Step Guide for Beginners, SAGE, 2005.
2. Geoffrey R. Marczyk, David DeMatteo & David Festinger, Essentials of research Design and Methodology, John Wiley and Sons, 2004.
3. John W Creswel, Research Design- Qualitative, Quantitative and Mixed Methods Approaches, SAGE, 2004.
4. Suresh C. Sinha and Anil K Dhiman, Research Methodology (2 volume-set), Vedam Books, 2006.
5. Kothari C. R., Research Methodology- Methods and Techniques, New age International Publisher, 2008.


### MME 5175 ADVANCED MANUFACTURING TECHNOLOGY [3 1 0 4]

AJM, WJM, AWJM and USM working principles, Equipment, Process parameters, Electrical EDM & WEDM - working principles, Equipment, Process parameters, CHM and ECM working principles, Equipment, Process parameters, LBM, PAM, EBM- working principles, Equipment, Process parameters, Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting, Electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW), Details of high energy rate forming (HERF) process, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Stretch forming, and contour roll forming, 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 Pretice Hall.


### MME 5172 ADVANCED MATERIALS AND CHARACTERIZATION [3 1 0 4]

Mechanical Behavior of Materials: Plastic deformation, strengthening mechanisms, damping properties of materials, Propagation of fatigue cracks, Creep mechanisms - Environmental degradation of materials, Selection of materials. Engineering Alloys: Ferrous and non-ferrous 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, SMART materials. Polymeric Materials: Polymeric materials, polymeric structure, properties and applications. Advanced structural ceramics. Surface Modifications of Materials: Mechanical surface treatment and coating – coatings for improving the mechanical properties of material surfaces. Nonmetallic Materials: Composite materials, ceramics and plastics, types and applications. Characterization of Materials: Optical microscopy, X-Ray diffraction, Scanning electron microscopy, Transmission electron microscopy principles, Selected area diffraction, chemical analysis and thermal analysis methods. Characterization of Surfaces: Characterization of surface microstructure & properties, Measurement of coating thickness, Measurement of residual stress & stability, Spectroscopic analysis of modified surfaces.

**References:**


1. Callister W.D. (2013), Material Science and Engineering- An introduction, Wiley – Eastern, 9th Edition.
2. Thomas H. Courtney, (2000), Mechanical Behavior of Materials, McGraw Hill.
3. Davis, J.R., (2001), Surface Engineering for corrosion and wear resistance, ASM International.
4. Raghavan, V. (2003), Physical Metallurgy, Prentice Hall of India.

### MME 5173 FLUID POWER AUTOMATION [3 1 0 4]

Introduction to pneumatic systems, Advantages and limitations, Components of 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, magnetic, inductive, capacitive, optical, ultrasonic, pneumatic proximity sensors Design of electro pneumatic circuits, Introduction to Hydraulic systems, Hydraulic actuators and accessories, Linear actuators, calculation of force, speed, rotary actuators, accumulator, Hydraulic valves, Construction and working of various types of Direction control valves, Hydraulic circuits.

**References:**


1. Werner Deppert and Kurt Stoll, Pneumatic Control, VOGEL Buchverlag Wurzburg, Germany, 1992.
2. Majumdar S.R., Pneumatic Systems Principles and Maintenance, Tata McGraw Hill, New Delhi, 2000.
3. Peter Croser, Frank Ebel, Pneumatics Basic Level TP 101, Festo Didactic GMBH & Co, Germany, 2002.
4. Prede G. and Scholz D., Electro pneumatics Basic Level, Festo Didactic GMBH & Co, Germany, 2002.
5. Hasebrink J.P. and Kobler R., Fundamentals of Pneumatic Control Engineering" Festo Didactic GMBH & Co, Germany, 2002.


### MME 5174 THEORY OF METAL CUTTING [3 1 0 4]

Cutting tool nomenclature, Nomenclature of single point tool, multi-point tool, Effect of cutting parameters on tool geometry, Indexable inserts, ISO specification of tool holders and inserts. Cutting Tool Materials, Desirable properties of tool materials, Mechanics of metal cutting, Mechanisms of chip formation – ductile and brittle materials, Ploughing force, Forces in Machining: Forces in turning, drilling and milling, Measurement of cutting forces – Cutting tool dynamometer, Thermal aspects in metal cutting, Heat sources in metal cutting, Temperature in chip formation, temperature distribution, Properties of cutting fluids, Cutting tool wear and tool life, Different wear mechanisms, reasons for failure of cutting tools, Theory of chatter, Effects of vibration, sources of vibration, Analysis of single and two degrees of freedom chatter.

**References:**


1. Amitabh Bhattarcharya, Metal Cutting-Theory and Practice, New central Book Agency Pvt. Ltd., Kolkata, 1984.
2. M.C. Shaw, Metal cutting principles, Oxford Publication, 1980.
3. Boothroyd, Fundamentals of Metal Machining, McGraw-Hill Book Company, 1985.
4. B.L. Juneja ,G. S. Sekhon, Fundamentals of Metal cutting & Machine Tools, New Age International (p) Ltd, Second Edition, 2003.
5. V.C. Venkatesh, S. Chandrasekharan, Metal cutting, Prentice Hall, 1985.


### MME 5169 ADVANCED MATERIAL TESTING 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 specimens, Tensile test specimen preparation from the above heat treated specimens, Hardness test for above specimens (Brinel and Rockwell), Wear test, Non-destructive testing, Demonstration on two-high hand operated rolling mill, Analysis using SEM and XRD, use of Autoclave for manufacturing composite material.

**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 Mc graw hill edition, 1997


### MME 5170 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.

Mini Project work (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.


## SEMESTER II

### MME 5275 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.

### MME 5276 PRODUCTION AUTOMATION [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.

**References:**


1. Radhakrishnan P., Computer Numerical Control Machines, New Central Book Agency (P) Ltd.,Kolkata, 2004.
2. GrooverMikell 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 Compay, New Delhi, 2009.
5. Thomas Crandell M., CNC Machining and Programming, an Introduction, Industrial Press Inc., New York, 2002.


### MME 5284 FINITE ELEMENT ANALYSIS LAB [0 0 3 1]

FEA using ANSYS classic/ workbench, truss analysis, beam analysis, 2D and 3D structural analysis, thermal analysis, Thermo-mechanical analysis of single point cutting tool; Thermo-mechanical analysis of reamer; 2D Finite element simulation of orthogonal cutting.

**References:**


1. Daryl L Logan, A first course in Finite Element Method, (4e), Thompson Ltd. India, 2007.
2. Segerlind Larry J., Applied finite element analysis, John Wiley, 1984.
3. David W. Nicholson, Finite Element Analysis – Thermo mechanics of Solids, CRC Press Ltd, Washington DC, 2003.


### MME 5263 INDUSTRIAL AUTOMATION LAB [0 0 3 1]

Pneumatic controls: pneumatic and electro-pneumatic components and its application circuit, Hydraulic controls: Hydraulic and electro-hydraulic components and its application circuit, CNC Programming: Manual and CAM software based programming for CNC turning and Machining centre, Computer Aided Inspection (CAI), Practice of measuring/inspection using CMM, Robot.

**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.


## PROGRAM ELECTIVES

### MME 5004 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.


### MME 5005 FINITE ELEMENT METHODS [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.

**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.


### MME 5010 ADDITIVE MANUFACTURING

Introduction to Additive Manufacturing: General overview, Traditional manufacturing vis AM Computer aided design (CAD) and manufacturing (CAM) and AM. Different AM processes and relevant process physics. AM process chain. Application level of AM: Direct processes and Indirect Processes. Materials science for Additive Manufacturing: Different materials used in AM, Role of solidification rate, Structure property relationship, Grain structure and microstructure. Additive Manufacturing

Technologies: Powder-based AM processes, Printing processes (droplet based) 3D Solid-based AM processes, object Stereo lithography. Micro and Nano AM. Mathematical models in Additive Manufacturing: Transport phenomena models, Numerical Modeling of AM process, Powder bed melting based process, Droplet based printing process Residual stress, part fabrication time, cost and optimal orientation. Process Selection, planning and control of Additive Manufacturing: Selection of AM technologies using decision methods. Additive manufacturing process plan strategies and post processing. Defect in AM and role of transport. Monitoring and control of defects.

**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, Laser-assisted fabrication of materials, Springer Series in Material Science, e-ISBN: 978-3-642- 28359-8.
4. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, InTech, 2012.
5. C.K. Chua, K.F. Leong and C.S. Lim, Rapid prototyping: principles and applications, 3rd Edition, World Scientific, 2010.


**MME 5011 ADVANCED METAL CASTING AND JOINING**

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, Weld defects, Brazing and Soldering. Welding Metallurgy: Heat flow in welding, Metallurgical transformation in and around weld ment, Implication of cooling rates, Heat affected zone (HAZ), Weldability of steels, Design of weld ments, 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. Serope Kalpakjian 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.


**MME 5012 ADVANCED HEAT TREATMENT [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.


**MME 5013 DESIGN FOR MANUFACTURING [ 3 1 0 4 ]**

Phases of design, essential factors of design, design and manufacturing, advantages of DFMA in product design, selection of materials and processes. Characteristics and design guidelines for sand casting, investment casting, die-casting, investment moulding and forging. Characteristics and design guidelines for manufacture of sheet metal and powder metal parts with examples. Design for machining - characteristics and design guidelines for turning, drilling, reaming, shaping, slotting, milling, grinding, honing, lapping, super finishing and advanced machining processes. Characteristics of manufacturing process and design guidelines for plastics, rubbers, ceramics and glass components. Process engineering - designing for heat treatment, sequence of operations for manufacturing of round and flat type components. Dimensioning for manufacturing, Fits, tolerance and surface finish consideration in design, Preparation of manufacturing drawings of components of various products.

**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. Chitale A. K. and Gupta R. C., Product Design and Manufacturing, PHI Pvt. Ltd., New Delhi, 2005.
5. Corrado Poli, Design for Manufacturing- A Structured Approach, Butterworth-Heinemann Ltd., 2001.

### MME 5014 FRACTURE MECHANICS [3 1 0 4]

Fracture mechanics approach to design, brittle and ductile fracture, effect of material properties on fracture. Linear Elastic Fracture Mechanics- fracture modes, fracture criteria, mechanisms of fracture & crack growth, griffith's analysis, energy release rate (G), elastic crack tip fields, stress intensity factor, Crack tip plasticity -Irwin approach, strip yield model, plastic zone shape and size, plane strain fracture toughness. Elastic-Plastic Fracture Mechanics - J-integral, HRR fields, J-controlled crack growth, Crack tip opening displacement. Fracture toughness testing of metals - KIc test, JIc measurement, determination of critical CTOD. Fatigue Fracture Mechanics - Fatigue crack growth, crack closure and fatigue threshold, crack growth behavior under variable amplitude loading, effect of overload, prediction of fatigue crack growth and & life of a structural component. Fail safety and damage tolerance - damage tolerance approach of failsafe design, fracture safe design of thick & thin pressure vessels, leak before break, dynamic fracture mechanics, mixed mode fracture initiation and growth, Applications of fracture mechanics to engineering design, FEA of cracks in solids.

**References:**


1. Anderson T. L., Fracture Mechanics-Fundamentals and applications, (3e), CRC Press, London, 2005.
2. Richard W Hertzberg, Richard P Vinci and Jason L Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, (5e), John Wiley & Sons, 2012.
3. Broek D., The Practical Use of Fracture Mechanics, Springer Netherlands, 1989.
4. Prashant Kumar, Elements of Fracture Mechanics, McGraw Hill Education Private Limited, 2013.
5. Norman E Dowling, Mechanical Behaviour of Materials, (4e), Prentice Hall, 2012.


### MME 5015 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.
5. Kishan K. Chawla, Composite materials – Science and Engineering, Springer, 2012


## OPEN ELECTIVES

### MME 5053 CORROSION SCIENCE [3 0 0 3]

Definition of corrosion, Importance of corrosion study, Costs of corrosion, Corrosion environments, Corrosion damage, Classification of corrosion, Factors influencing corrosion rate. Uniform corrosion, Galvanic or two metal corrosion, Crevice corrosion, Pitting corrosion, Inter-granular corrosion, Selective leaching, Erosion corrosion, Stress corrosion, Hydrogen damage. Corrosion testing, Purpose, Materials and specimens, Surface preparation, measuring and weighing, Exposure techniques, Duration, Planned interval tests, Aeration, Cleaning specimens after exposure, Standard expressions for Corrosion rate. Corrosion prevention, Materials selection – Metals and alloys, Metal purification, non-metallics, Change of environments – Changing the medium, Use of Inhibitors, Design improvements, Cathodic and anodic protection, Coatings – metallic coating, inorganic coating, organic coating, failure analysis. Corrosion Principles, Electrochemical theory of corrosion, Applications of thermodynamics to corrosion, Free energy, activation energy, Polarization of corrosion reactions, Activation polarization, Concentration polarization, Combined polarization, Pourbaix diagram (E/pH diagram) passivity, Corrosion rate measurements – Tafel extrapolation and Liner polarization techniques

**References:**


1. Mars G. Fontana, Corrosion Engineering, Third edition Tata McGraw Hill, New Delhi.
2. Zaki Ahmed, Principles of Corrosion Engineering and Corrosion Control, Elsevier Science and Technology Books, 2006.
3. K. R. Trethewey and J. Chamberlain Longman, Corrosion for students of science and engineering, Scientific & Technical New York, USA.
4. Schweitzer Philip A, Fundamentals of Corrosion-Mechanisms, Causes and Preventive Methods, CRC Press, Tayler and Francis Group, Boca Raton, 2010.
5. Pierre R. Roberge, Corrosion Engineering – Principles and practices, Gulf publishing company.


### MME 5054 CREATIVITY FOR PRODUCT DESIGN [3 0 0 3]

Introduction to Product Design - Product Design Process, design by innovation, creativity in design, strength considerations in product design. Tools for design: Information-based tools, Procedure-based tools, Quality Function Deployment, Taguchi technique for robust design, Design for Manufacture, Rapid prototyping; Embodiment design. Creative thinking - The five dimensions of creativity, synthesis, evolution, revolution, re-application and change, creative thinking tools for idea generation and problem solving, convergent and divergent, theory of inventive problem solving. Basic Probability concepts- Basic probability theory, Central Limit Theorem, probability mass function, cumulative distribution function, probability density function. Reliability of Components and Systems- reliability theory, reliability management, history of reliability engineering; reliability allocation, reliability testing.

**References:**


1. Ulrich Karl T. and Eppinger Steven D., Product Design and Development, McGraw Hill International Edition, 1999.
2. Rosenthal Stephen, Effective Product Design and Development, Business One Orwin Homewood, 1992.

3. Dieter, Engineering Design, McGraw Hill International Edition, 1990.
4. Day Ronald G., Quality Function Deployment, Tata McGraw Hill, 1990.
5. Goldenberg and Mazursky, Creativity in Product Innovation, Cambridge University Press, 1996.

### MME 5055 DESIGN OF EXPERIMENTS [3 0 0 3]

Understanding basic 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, 2k, designs, Implementing confounding and blocking in 2k 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.

### MME 5057 INDUSTRIAL SAFETY ENGINEERING [3 0 0 3]

Industrial revolution; Milestones in the safety movement; Accidents & their effects; Cost of accidents; Theories of accident causation - Domino theory, Human factor theory, Accident/incident theory, Epidemiological theory, System theory, Industrial Hazards Ergonomic Hazards; Mechanical Hazards; Fall and impact hazards; Temperature hazards; National Safety Council India (NSCI) and Industrial Safety Acts: Introduction to NSCI; Mission and Vision; Milestones; Management; NSCI safety award schemes; Safety audits; Risk assessment; NSCI safety rating system; Hazard and operational (HAZOP) studies, Industrial Safety Analysis and Management, Preliminary hazard analysis; Detailed hazard analysis; Failure mode and effect analysis (FMEA); Human error analysis (HEA); Environmental Safety: Safety, health and environment.

**References:**

1. David L. Goetsch, Occupational Safety and Health for Technologists, Engineers and Managers, 5th Edition, Pearson-Prentice Hall, 2005.
2. Frank R. Spellman and Nancy E. Whiting, The Handbook of Safety Engineering: Principles and Applications, The Scarecrow Press Inc., 2010
3. Amit Kumar Gupta, Industrial Safety and Environment, Laxmi Publications (P) Ltd., 2006
4. National Safety Council India, "NSC," [Online]. Available: http://nsc.org.in/.
5. Ministry of Labour and Employment, "Ministry of Labour and Employment," [Online]. Available: http://nsc.org.in/.

### MME 5058 LEAN MANUFACTURING [3 0 0 3]

The production system, types, inception &necessity of lean production system, lean revolution in Toyota, basic image of lean production, Principles & characteristics of lean manufacturing, MUDA(waste) and types, lean manufacturing tools and techniques, cellular manufacturing, Continuous improvement, Just-In-Time, production smoothing, Overall equipment efficiency, standardized work and KAIZEN, Standardization of operations, Multi-function workers and job rotation, Improvement activities to reduce work force and increase worker morale foundation for improvements, Shortening of production lead times.

**References:**

1. Chasel Aquilino, Productions and Operations Management, Dreamtech latest edition.
2. Yasuhiro Monden , Toyoto Production System -An integrated approach to Just in Time, Engineeringaild Management Press - Institute of Industrial Engineers Norcross Georgia, 1983.
3. James P Womack - Daniel T Jones- and Daniel Roos, The Machine that changed the World. The Story of Lean Production - -Harper Perennial - edition published, 1991.
4. James Womack, Lean Thinking - ISBN 0743249275, 2003.
5. Richard Schourberger, Japanese Manufacturing Techniques. The Nine Hidden Lessons by simplicity - ASQC Press, 1991.

### MME 5059 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 bio-conversion – 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:**

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