M.TECH – MANUFACTURING ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

Manufacturing Sector is the engine of growth for our country and it provides a stable economy. According to the technology road map 2035, the manufacturing sector in India needs to grow through adoption of technology platforms which include nano engineering, additive manufacturing, adaptive automation, precision manufacturing and sustainable manufacturing. The Industry needs the skill and creativity to manufacture complex, high specialization products. This program provides an in depth understanding of wide range of domains from general welding, forming, casting and cutting to highly specialized additive manufacturing concepts and is an important link for industrial competitiveness.

The syllabus for various courses has been designed in general to introduce the application of analytical and quantitative methods in manufacturing and to train the students to develop skills in the utilization of the modern tools such as simulation, optimization, statistical data analysis, and finite element analysis. During the course of study, the students will acquire knowledge and skills to solve practical problems encountered in manufacturing.

CURRICULUM

First Semester

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<tr>
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Credits 20

*Non credit course

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**Total credits:** 65

### List of Courses

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#### Subject Core

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**Project Work**

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Review of Probability Concepts and Random Variables
Analysis of Variance: One way and two way analysis of variance. Fixed and random efforts models-Multiple comparison test for one way analysis. Completely randomized block design-Latin square design – Two factor factorial design – Model with main and interaction efforts and analysis.

Matlab, SageMath: Problems in Analysis of Variance and PDE

TEXT BOOKS / REFERENCES:


Materials characterization techniques – EDS, XRD, SEM, TEM, AFM and NDT – radiography and ultrasonic testing, Liquid Penetrant test, Magnetic particle and Eddy current testing. Codes, Standards and Case Studies.

TEXT BOOKS/ REFERENCES:

18ME602 ANALYSIS OF MACHINING PROCESSES 2-0-2-3


Machining forces: Cutting force components in turning, milling and drilling - Construction of Merchant Circle Diagram - Cutting power consumption and specific energy requirement - Analytical models for estimation of cutting forces in orthogonal and oblique cutting – Measurement of cutting forces.


Machining dynamics: Machine tool vibration - Vibration analysis methods- Chatter prediction - Vibration control - Frequency response functions and stability lobe plots – Vibration based condition monitoring of machine tools – Machining dynamics in High speed machining, Thin wall machining and High performance machining - Machining economics and optimization.

Lab: Chip Morphological studies, Cutting force measurement in turning, milling and drilling using dynamometers, Vibration / AE based machine condition monitoring, Experiments related to stability lobes, Process modelling of machining process using Finite Element Packages.

Use of Codes, Standards in machining.

TEXT BOOKS/ REFERENCES:

18ME603 THEORY OF PLASTICITY AND METAL FORMING

Metallurgical aspects of metal forming-slip, twinning mechanics of plastic deformation-effects of temperature, strain rate, microstructure and friction in metal forming - yield criteria and their significance-classification of metal forming processes-advantages and limitations-stress strain relations in elastic and plastic deformation-concept of flow stresses-deformation mechanisms-hot and cold working processes and its effect on mechanical Properties.
Fundamentals of metal working: Classification of forming processes, mechanics of metal working, flow stress determination, temperature in metal working, strain-rate effects, metallurgical structure, friction and lubrication. Forging: Classification, forging in plane strain, calculation of forging loads, forging defects: incomplete die filling, die misalignment, laps, incomplete forging penetration, microstructural differences, hot shortness, pitted surface, surface cracking, micro cracking due to residual stresses
Rolling of metals: Classification, hot and cold rolling, forces and geometrical relationships, simplified analysis of rolling load, rolling variables, problems and defects in rolled products: centreline cracking, warping, edge wrinkling, edge cracking, centre splitting, centreline wrinkling- torque and power.
Extrusion: Classification, deformation, lubrication, defects, analysis of extrusion process.
Drawing of rods, wires and tubes: Introduction, analysis of wire and tube drawing, residual stresses.
Sheet metal forming: Introduction, forming methods, shearing, blanking, bending, stretch forming, deep drawing, forming limit criteria, defects in formed parts. Codes and Standards

TEXT BOOKS/REFERENCES:

18ME650 MANUFACTURING AUTOMATION

Introduction to Automation - Automated manufacturing systems. Sensors and Actuators in Automation - Digital and analog sensors; Fluid power actuators; Control valves; Electrical system elements; Motors drives; Mechanical devices. Control Using PLCs - Relay logic; Combinational and sequential control; Minimization of logic equations; Ladder logic diagrams; Programmable logic controllers (PLCs); PLC components; Programming; I/O addresses; Timer and counters; A/D conversion and sampling; PLC applications. Pneumatic and Hydraulic
Systems - Pneumatic fundamentals - control elements, position and pressure sensing - logic circuits - switching circuits - sequential circuits - cascade method. Material Handling - Mechanization devices and material handling systems; Mechanization of parts handling; Parts feeding; Parts sensing; Automated Guided Vehicle.


Data Monitoring using Arduino/Raspberry Pi: Basic structure - Input / Output processing - Programming - Mnemonics Timers, Internal relays and counters - Analog-to-Digital (A/D) and Digital-to-Analog (D/A) Conversion - Analog input / output, Programming and interfacing with Sensors in manufacturing applications using Python.


TEXT BOOKS/ REFERENCES:

18ME661 MANUFACTURING ENGINEERING LAB 1 0-0-2-1

Machining and forming: Machining: Forces in turning, drilling, milling and grinding, study of process parameters and its effects. Press working- load calculations for blanking, bending and forming operations and practise.
CNC Programming and practice.
Metal joining: Welding: –Study and practise of GMAW &GTAW processes for various Metals and alloys like Stainless steel etc.
Metallographic Studies: similar/dissimilar weldments.

18ME651 ADVANCED CASTING AND WELDING TECHNOLOGY 3-0-1-4
for casting processes. Simulation of these processes using software packages. Prediction of casting defects-porosity, segregation, shrinkage and hot tearing.


Lab: Numerical Analysis using Multi Physics Software.

TEXT BOOKS/ REFERENCES:

18ME652 LEAN MANUFACTURING 3-0-0-3

Quality Key #2: Improve Your Processes Key #3: Work Together for Maximum Gain Key #4: Base Decisions on Data and Facts - Five Laws of Lean Six Sigma - Case Studies.

Ergonomics-as enabler of lean manufacturing, Ergonomic consideration at work, Principles related to: the use of human body, the arrangement of workplace, the design of tools and equipments

TEXT BOOKS/ REFERENCES:

18ME653 ADVANCES IN MANUFACTURING TECHNOLOGY 3-0-0-3


Surface modification Techniques: Physical and chemical vapour deposition techniques, thermal spray coating processes, vacuum arc deposition, sputter deposition, surface hardening, e-beam, laser and plasma processing, diffusion bonding, hot isostatic pressing,

TEXT BOOKS/ REFERENCES:

18ME662  MANUFACTURING ENGINEERING LAB II  0-0-2-1

System Simulation:
Modeling and analysis of manufacturing and materials handling systems and service systems through simulation - ARENA.
Analysis of simulation input data and fit the data into a suitable distribution using ARENA Input Analyzer – Simulation output analysis - Performance Modelling of Assembly shops, FMS, Flow shop, Jobshops, and Kanban Controlled Manufacturing Systems – Modeling of material handling systems - Simulation optimization.

18ME663  MANUFACTURING ENGINEERING LAB III  0-0-2-1

CAD: Exercises covering sketching, modelling, assembly, interference checking, drafting, generation of BOM. Exercises involving customization of CAD software using VB programming.
Geometric Dimensioning and Tolerance- Standards and Codes.
FEA: Exercises covering structural analysis, dynamic analysis using and thermo mechanical coupled analysis FEA packages– Finite element modelling of metal forming and metal cutting operation.

18ME654  ADDITIVE MANUFACTURING  2-0-2-3

Introduction to layered manufacturing, Importance of Additive Manufacturing Additive Manufacturing in Product Development. Classification of additive manufacturing processes, Common additive manufacturing technologies; Fused Deposition Modeling(FDM), Selective Laser Sintering(SLS), Stereo Lithography(SLA), Selection Laser Melting (SLM), Jetting, 3D Printing, Laser Engineering Net Shaping (LENS), Laminated Object Manufacturing (LOM), Electron Beam Melting (EBM). Capabilities, materials, costs, advantages and limitations of different systems.
Material science for additive manufacturing-Mechanisms of material consolidation-FDM, SLS, SLM, 3D printing and jetting technologies. Polymers coalescence and sintering, photo polymerization, solidification rates,Meso and macro structures, Process evaluation: process-structure relationships, structure property relationships,
Applications: Prototyping, Industrial tooling, Aerospace, Automobive, Medical etc.,
Quality control and reliability: Defects in FDM, SLS and SLM, Critical process parameters: geometry, temperature, composition, phase transformation, Numerical and experimental evaluation: roles of process parameter combination, process optimization.
CAD Modelling for 3D printing: , 3D Scanning and digitization, data handling & reduction Methods, AM Software: data formats and standardization, Slicing algorithms:-uniform flat layer
slicing, adaptive slicing, Process-path generation: Process-path algorithms, rasterisation, part
Orientation and support generation.

Lab: CAD Modeling: Introduction to CAD environment, Sketching, Modeling and Editing
features, Different file formats, Export/Import geometries, Part orientation, Layer slicing,
Process path selection, Printing, Numerical and experimental evaluation.

TEXT BOOKS/ REFERENCES:
3. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications : A tool box
5. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications,

18RM600 RESEARCH METHODOLOGY 2-0-0 2

Unit I:
Meaning of Research, Types of Research, Research Process, Problem definition, Objectives of
Research, Research Questions, Research design, Approaches to Research, Quantitative vs.
Qualitative Approach, Understanding Theory, Building and Validating Theoretical Models,
Exploratory vs. Confirmatory Research, Experimental vs Theoretical Research, Importance of
reasoning in research.

Unit II:
Problem Formulation, Understanding Modeling & Simulation, Conducting Literature Review,
Referencing, Information Sources, Information Retrieval, Role of libraries in Information
Retrieval, Tools for identifying literatures, Indexing and abstracting services, Citation indexes

Unit III:
Experimental Research: Cause effect relationship, Development of Hypothesis, Measurement
Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of
Experiments, Field Experiments, Data/Variable Types & Classification, Data collection,
Numerical and Graphical Data Analysis: Sampling, Observation, Surveys, Inferential Statistics,
and Interpretation of Results

Unit IV:
Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing
the abstract, introduction, methodology, results and discussion, conclusion sections of a
manuscript. References, Citation and listing system of documents

Unit V:
Intellectual property rights (IPR) - patents-copyrights-Trademarks-Industrial design
geographical indication. Ethics of Research- Scientific Misconduct- Forms of Scientific
Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science
18MA610  OPTIMIZATION TECHNIQUES IN ENGINEERING  2-0-2-3


Implementing optimization algorithm using Matlab / Programming: Design optimization - Robust design - Optimization in manufacturing / machining – Multi objective optimization - Structural optimization - Shape optimization - Optimization in production planning and control.

TEXT BOOKS/ REFERENCES:

Structural dynamics: Formulation - Element mass matrices - Evaluation of Eigen values and Eigen vectors - Natural frequencies and mode shapes - Numerical time integration.

Computer implementation of the Finite element method: pre-processing, element calculation, equation assembly, Solving, Post processing – primary and secondary variables. Introduction to computational packages.

TEXT BOOKS/REFERENCES:

18ME702 SURFACE ENGINEERING 3-0-0-3

Introduction to surface engineering-Classification of surfaces and properties-Surface degradation, Wear and Corrosion - types of wear-Roles of friction and lubrication-Overview of different forms of corrosion-Surface treatment and coating: Chemical and Electrochemical polishing, Chemical conversion coatings, Phosphating, Chromating, Chemical colouring, Anodizing of aluminium alloys- Thermo chemical processes-Surface pre-treatment-Deposition of copper, zinc, nickel and chromium - principles and practices-Alloy plating, Electro composite plating, Electro less plating of copper, nickel phosphorous, nickel-boron, electro less composite plating, application areas- Physical/Chemical vapour deposition, Plasma spray coating; Plasma assisted ion implantation, Surface modification by directed energy beams like Ion, Electron and Laser beams, Energy transfer, Beam configuration and modes-Solid lubricants coating and Surface corrosion resistance-Micro arc oxidation/Plasma electrolytic oxidation process-Diffusion phenomenon and equation-Effects of phase transformation-Simulation of surface modification processes-Solutions for practical problems-Novelty of composition and microstructure-Post irradiation characterization and testing/evaluation of surface, Properties, Structure and Property Correlation-Failure mechanisms

ASTM Standards for Mechanical and Tribological Testing

TEXT BOOKS/ REFERENCES:
18ME703   DESIGN OF EXPERIMENTS                3 0 0 3

Introduction to Research, Review of linear estimation, basic designs and Design Principles, Completely Randomized Designs, Treatment Comparisons, Diagnostics and Remedial Measures, Experiments to Study Variances, Random Effects Models. Factorial Designs: General factorial experiments, factorial effects; best estimates and testing the significance of factorial effects; study of 2^n and 3^r factorial experiments in randomized blocks; complete and partial confounding, construction of symmetrical confounded factorial experiments, fractional replications for symmetrical factorials, split plot and strip-plot experiments. Complete Block Designs: Balanced incomplete block designs, simple lattice designs, Two-associate partially balanced incomplete block designs: association scheme and intra block analysis, group divisible design. Analysis of Covariance including a Measured Covariate Split-Plot Designs, Repeated Measures Designs, missing plot technique:- General theory and applications, Analysis of Covariance for CRD and RBD. Application areas: Response surface experiments; first order designs, and orthogonal designs; clinical trials, treatment-control designs; model variation and use of transformation; Tukey’s test for additivity.

TEXT BOOKS/ REFERENCES:

18ME704   PRODUCTION AND OPERATIONS MANGEMENT 3-0-0-3


TEXT BOOKS/ REFERENCES:

18ME705 LOGISTICS AND SUPPLY CHAIN MANAGEMENT 3-0-0-3


TEXT BOOKS/REFERENCES:

18ME706 COMPOSITE MATERIALS AND PROCESSING 3-0-0-3

Fabrication techniques: infiltration, casting, reaction sintering, electro-deposition, diffusion bonding, thermal and plasma spray forming, laser method, powder forming, additive processes, crystal growth and physical vapour deposition. Testing and inspection methods. Laminated Composites, Sample level lamination, case studies. Experimental techniques, compositional analyses (introduction) and qualification of composites. Instrumental characterization and introduction to advanced characterization techniques (XRD, XRF, ITFR, SEM, TEM, TGA etc). Non-Destructive Analyses of Composites.

TEXT BOOKS/ REFERENCES:

18ME707  PRODUCT LIFECYCLE MANAGEMENT  3-0-0-3


TEXT BOOKS/ REFERENCES:

18ME708  TOOL ENGINEERING AND DESIGN  3-0-0-3

TEXT BOOKS/ REFERENCES:

18ME709 RELIABILITY ENGINEERING 3-0-0-3


TEXT BOOKS/ REFERENCES:

TEXT BOOKS/ REFERENCES:

version control – library creation – catalogue making – standardization for design – collaborative design among peer groups – design optimization for geometry - Design check, approval and validation. – introduction to design patenting rules. Geometric dimensioning and tolerancing.

TEXT BOOKS/ REFERENCES:

18ME712  QUALITY ENGINEERING  3-0-0-3


Process evaluation and control by designs of experiment: Various basic designs; Special methods such as EVOP and ROBUST design (Taguchi Methods). Six Sigma Management: Concepts, Steps and Tools; Benchmarking and Balanced Score Cards. TPM, FMECA, Fault Tree Analysis, Quality and reliability perspectives of JIT. Training for Quality. Application of Software tools and Case Studies.

TEXT BOOK/ REFERENCES:

18ME713  ADVANCED MATERIALS FOR AEROSPACE AND  3-0-0-3
NUCLEAR APPLICATIONS
Detailed study and equipment design for advanced and high tech material processing: Introduction, definition and classification of different types of Engineering Materials for aerospace, space, nuclear and defence applications (such as: Titanium alloys, super alloys, aluminium & light alloys, composites, tungsten–tantalum alloys, Moly and PM)
Elaborate study on properties, Composition and processing techniques of advanced materials, Layout of advanced processing techniques, classification, application and importance, Additive manufacturing, 3D metal printing, laser and electron beam processing, vacuum induction, electro-slag, vacuum arc, and controlled atmosphere processing.
Joining technologies for space and aerospace: EBW, Diffusion bonding, vacuum brazing, friction based joining techniques, atmosphere controlled joining of aero engine components, heavy alloy powder processing, functionally gradient materials
Aero-structures and nuclear power plant structural study, design of material for the same

TEXT BOOK/ REFERENCES:
5. Material science and engineering, Vol III, aerospace and space materials, M Peter and C Leyens, EOLSS, UNESCO