

M.TECH –MANUFACTURING ENGINEERING

Department of Mechanical Engineering

This program focuses on the requirements of the manufacturing industry embracing the areas of production planning and control, design, materials, processes and quality control. The curriculum has been framed drawing course contents from traditional fields such as materials and processes, mechanical engineering, industrial engineering, and management. 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

Course Code	Type	Course	L T P	Cr
MA604	FC	Stochastic Process and Partial Differential Equations	3 0 1	4
ME600	FC	Materials Science and Engineering	3 0 1	4
ME601	FC	Analysis of Machining Processes	3 0 0	3
ME602	FC	Theory of Plasticity and Metal Forming	3 0 0	3
ME650	SC	Manufacturing Automation	3 0 1	4
ME661	SC	Manufacturing Engineering Lab I	0 0 1	1
HU601	HU	Cultural Education*		P/F
Credits				19

*Non-credit course

Second Semester

Course Code	Type	Course	L T P	Cr
ME651	SC	Advanced Casting Technology	3 0 0	3
ME652	SC	Lean Manufacturing	3 0 0	3
ME653	SC	Metrology and Computer Aided Inspection	3 0 0	3
	E	Elective I	3 0 0	3
	E	Elective II	3 0 0	3
ME662	SC	Manufacturing Engineering Lab II	0 0 1	1
ME663	SC	Manufacturing Engineering Lab III	0 0 1	1
EN600	HU	Technical Writing*		P/F
Credits				17

*Non-credit course

Third Semester

Course Code	Type	Course	L T P	Cr
ME654	SC	Production and Operations Management	3 0 0	3
	E	Elective III	3 0 0	3
ME799	P	Dissertation		10
Credits				16

Fourth Semester

Course Code	Type	Course	L T P	Cr
ME799	P	Dissertation		12
Credits				12

Total Credits: 64

List of Courses
Foundation Core

Course Code	Type	Course	L T P	Cr
MA604	FC	Stochastic Process and Partial Differential Equations	3 0 1	4
ME600	FC	Materials Science and Engineering	3 0 1	4
ME601	FC	Analysis of Machining Processes	3 0 0	3
ME602	FC	Theory of Plasticity and Metal Forming	3 0 0	3

Subject Core

Course Code	Course	L T P	Cr
ME650	Manufacturing Automation	3 0 1	4
ME651	Advanced Casting Technology	3 0 0	3
ME652	Lean Manufacturing	3 0 0	3
ME653	Metrology and Computer Aided Inspection	3 0 0	3
ME654	Production and Operations Management	3 0 0	3
ME661	Manufacturing Engineering Lab I	0 0 1	1
ME662	Manufacturing Engineering Lab II	0 0 1	1
ME663	Manufacturing Engineering Lab III	0 0 1	1

Electives

Course Code	Course	L T P	Cr
MA701	Optimization Theory	3 0 0	3
ME701	Finite Element Methods	3 0 0	3
ME702	Surface Engineering	3 0 0	3
ME703	Design of Experiments	3 0 0	3
ME704	Advanced Welding Technology	3 0 0	3
ME705	Embedded Systems	3 0 0	3
ME706	Advances in Manufacturing Technology	3 0 0	3
ME707	Logistics and Supply Chain Management	3 0 0	3
ME708	Composite Materials and Processing	3 0 0	3
ME709	Product Lifecycle Management	3 0 0	3
ME710	Tool Engineering and Design	3 0 0	3
ME711	Advances in Process Technology	3 0 0	3
ME712	Reliability Engineering	3 0 0	3
ME713	Financial Management	3 0 0	3
ME714	Computer Aided Product Development	3 0 0	3
ME715	Quality Engineering	3 0 0	3
ME716	Additive Manufacturing	3 0 0	3

Project Work

Course Code	Course	L T P	Cr
ME799	Dissertation		10
ME799	Dissertation		12

MA604 STOCHASTIC PROCESS AND PARTIAL DIFFERENTIAL EQUATIONS 3-0-1-4

Review of Probability Concepts and Random Variables

Random Processes: General concepts and definitions-Stationarity in random process-autocorrelation and properties-Poisson points, Poisson and Gaussian processes-Spectrum estimation- Ergodicity and mean Ergodic theorem-Power spectral density and properties. Markov processes –Markov Chains – Transition Probability matrix- Classification of states-Limiting Distributions. 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 effects and analysis. Partial Differential Equations: Basic definitions. Model Equations: Elliptic, Parabolic and Hyperbolic PDEs. Solving PDEs Numerically - Elliptic, Parabolic and Hyperbolic Equations. Finite Element Method.

Matlab: Problems in Analysis of Variance and PDE.

TEXT BOOKS / REFERENCES:

1. Papoulis A and Unnikrishna Pillai, “*Probability, Random Variables and Stochastic Processes*”, Fourth Edition, McGraw Hill, 2002.
2. Ravichandran, J., “*Probability and Statistics for Engineers*”, Wiley India, 2012.
3. Douglas C. Montgomery and George C. Runger, “*Applied Statistics and Probability for Engineers*”, John Wiley and Sons Inc., 2005.
4. Lawrence C. Evans, “*Partial Differential Equations*”, American Mathematical Society, 2010.
5. Gilles Aubert and Pierre Kornprobst, “*Mathematical Problems in Image Processing: Partial Differential Equations*”, Springer, 2006.

ME600 MATERIALS SCIENCE AND ENGINEERING 3-0-1-4

Interfaces: Classification, geometry and thermodynamics of interfaces. Coherent and non-coherent boundaries. Free energy of interfaces. Equilibrium shapes of surfaces.

Solidification: Thermodynamics of homogeneous and heterogeneous nucleation and kinetics of growth. Interface morphologies. Role of thermal gradient and growth rate. Derivation of non-equilibrium freezing equation. Treatment of segregation. Nucleation in the solid state: Classical treatment and analytical formulation. Contribution of strain energy. Modes of nucleation. Diffusion in Solid State: Diffusion equations for steady state and transient conditions. Analytical solutions of diffusion equation for simple, practical problems. Strengthening methods: Principles, types of second phases, process sequence, controlling factors. Quench hardening and tempering. Precipitation hardening. Maraging. Spinodal hardening. Dispersion hardening-metal matrix composites, types of matrices and reinforcements. Case studies. Recent advances in materials development-Entropy alloys: Functionally gradient materials, Shape memory alloys. Principles, properties and applications. Codes, Standards and Case Studies.

TEXT BOOKS/ REFERENCES:

1. Verhoeven J. D., “*Fundamentals of Physical Metallurgy*”, John Wiley and Sons, 1975.

2. Sinha, A. K., “*Physical Metallurgy Handbook*”, McGraw-Hill, 2002
3. Shewmon, P., “*Diffusion in Solids, Minerals, Metals*”, Materials Society, 1998.
4. Schwartz, M., “*New Materials, Processes, and Methods Technology*”, Taylor and Francis, 2006.

ME601

ANALYSIS OF MACHINING PROCESSES

3-0-0-3

Mechanics of machining: Introduction, Mechanism of material removal- Chip formation. Force components, empirical force models, shear plane and finite element models for chip formation. Friction in metal cutting- stress distribution on tool face. Measurement of shear plane angle. Shear stress, strain and strain rate. Specific energies and material stress levels in machining. Forces in turning, drilling, milling and grinding. Force Measurement using dynamometers. Thermal aspects: Thermal modeling- analytical models for steady-state temperatures, numerical models, temperatures in interrupted cutting, Temperature measurement. Tool wear- mechanisms and measurement - work piece and tool condition monitoring system- monitoring techniques - surface finish and its measurement. Machining Dynamics- types of machine tool vibration -vibration analysis methods-free and forced vibrations-self excited vibrations-single and multi degrees of freedom systems- continuous systems- vibration control - chatter prediction-stability lobes. Tool wear- mechanisms and measurement - surface finish and its measurement -work piece and tool condition monitoring system-vibration measurement - Transducers-condition monitoring techniques. Process Modelling and simulation of Manufacturing Processes: turning, milling, drilling and grinding. High-speed machining-tooling requirements- dynamics- machining of hard materials-advanced tool materials. Codes, Standards and Case Studies.

TEXT BOOKS/ REFERENCES:

1. David A. Stephenson and John S. Agapiou, “*Metal Cutting Theory and Practice*”, CRC Press, 2005.
2. Milton C. Shaw, “*Metal Cutting Principles*”, Oxford University Press, 2006.
3. Childs, T. H. C., Maekawa, K., Obikawa, T., and Yaman. Y., “*Metal Machining: Theory and Applications*”, Arnold Publishers, 2000.
4. Wit Grzesik, “*Advanced Machining Processes of Metallic Materials: Theory, Modelling and Applications*”, Elsevier, 2008.
5. Chattopadhyay, A.B., “*Machining and Machine Tools*”, Wiley India, 2011.

ME602

THEORY OF PLASTICITY AND METAL FORMING

3-0-0-3

Introduction to elasticity: Analysis of stress and strain; stress at a point; stress tensor; stress transformations; principal stresses; octahedral stress; equations of equilibrium. Strain tensor; principal strains; strain-displacement relations; compatibility conditions; constitutive equations. Theory of plasticity: Introduction; flow curve; true stress and true strain; yielding criteria for ductile metals; combined stress tests; yield locus; anisotropy in yielding; yield surface and normality; octahedral shear stress and shear strain; invariants of stress and strain; plastic stress-strain relations; two dimensional plastic flow; slip line field theory. 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; residual stresses in forgings. 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; 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, Standards and Case Studies.

TEXT BOOKS/REFERENCES:

1. Timoshenko, S. P. and Goodier, J. N., “*Theory of Elasticity*”, Third Edition, McGraw Hill, 1970.
2. Chakrabarthy, J., “*Theory of Plasticity*”, Third Edition, McGraw Hill, 2006.
3. Dieter, G. E., “*Mechanical Metallurgy*”, Third Edition, McGraw Hill, 1988.
4. Waboner, R. H. and Chenot, J. L., “*Metal Forming Analysis*”, Cambridge University Press, 2001.
5. Henry S.Valberg., “*Metal Forming*”, Cambridge University Press, 2010.

ME650

MANUFACTURING AUTOMATION

3-0-1-4

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. Elements of hydraulic systems such as pumps, valves, filters, reservoirs, accumulators, actuators, intensifiers etc. Selection of hydraulic fluid, practical case studied on hydraulic circuit design and performance analysis. Servo valves, electro hydraulic valves, proportional valves and their applications - hydro pneumatic circuits. Material Handling - Mechanization devices and material handling systems; Mechanization of parts handling; Parts feeding; Parts sensing; Automated Guided Vehicle. Industrial Robotics - Robot anatomy - Work volume - Drive systems - Sensors in robotics - Robot reference frames and coordinates and robot kinematics. End effectors: Mechanical and other types of grippers - Tools as end effectors - Robot end effectors interface. Robot kinematics. Typical applications of robots: material transfer, machine loading/unloading; processing operations; assembly and inspection. Lab Practice - Fluid power circuit simulation, PLC Programming, Robot Programming.

TEXT BOOKS/ REFERENCES:

1. Mikell P. Groover, “*Automation, Production Systems and Computer Integrated Manufacturing*”, Third Edition, Pearson Education, 2009.
2. Robert J. Schilling, “*Fundamentals of Robotics, Analysis & Control*”, Prentice Hall, 2009.

of Lean Principles / concepts / tools - Stockless Production. Tools of Lean Manufacturing- Continuous Flow - Continuous Flow Manufacturing and Standard Work Flow - 5S and Pull Systems (Kanban and ConWIP systems) - Error Proofing and Set-up Reduction – Total Productive Maintenance (TPM) - Kaizen Event examples. Value Stream Mapping – Current state and Future State- Ford Production Systems. Building a Current State Map (principles, concepts, loops, and methodology) - Application to the factory Simulation scenario. Key issues in building the Future State Map - Process tips in building the map and analysis of the customer loop, supplier loop, manufacturing loop and information loop - Example of completed Future State Maps Factory simulation – Implementation of lean practices - Best Practices in Lean Manufacturing. Six Sigma Fundamentals -Selecting Projects – Six Sigma Statistics - Measurement System Analysis - Process Capability - DMAIC – Define, Measure, Analyze, Improve, Control. Lean Six Sigma – Four Keys to Lean Six Sigma - Key #1: Delight Your Customers with Speed and 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.

TEXT BOOKS/ REFERENCES:

1. James P. Womack, Daniel T. Jones, and Daniel Roos, “*The Machine that Changed the World: the Story of Lean Production*”, Simon and Schuster, 1996.
2. Jeffrey K. Liker, “*Becoming Lean*”, Industrial Engineering and Management Press, 1997.
3. James P. Womack and Daniel T. Jones, “*Lean Thinking*”, Free Press-Business and Economics, 2003.
4. Rother M. and Shook J., “*Learning to See*”, The Lean Enterprise Institute, Brookline, 2003.
5. George, Michael. L. “*Lean Six Sigma: Combining Six Sigma Quality with Lean Speed*”, Tata McGraw Hill Education, New Delhi, 2002.
6. Larson, Alan, “*Demystifying Six Sigma : A Company-Wide Approach to Continuous Improvement*”, Jaico, Mumbai, 2007.

ME653 METROLOGY AND COMPUTER AIDED INSPECTION 3-0-0-3

Laser Metrology: Laser Interferometer, Alignment Telescope, laser scanners. On-line and in-process measurements-diameter, surface roughness, Micro holes, surface topography measurements, straightness and flatness measurement, speckle measurements. Computer Aided Inspection: High precision measurements–interfacing–software metrology–Automated visual inspection in manufacturing, contact and non-contact type inspection methods, Electrical field techniques, radiation techniques, ultrasonic - Atomic Force Microscopes (AFM), Talysurf instruments. Coordinate Measuring Machine: CMM Types, Applications - Non-contact CMM using Electro optical sensors for dimensional metrology - Non-contact sensors for surface finish measurements–Measurements/programming with CNC CMM– Performance evaluations – Measurement integration. Quality In Manufacturing Engineering: Importance of manufacturing planning for quality – initial planning for quality – concept of controllability: self controls – defining quality responsibilities on the factory flow – self inspection – automated manufacturing – overall review of manufacturing planning – process quality audits – quality and production floor culture. On-line Quality control: On-line feedback quality control variable characteristics-control with measurement interval, one unit, and

TEXTBOOKS/REFERENCES:

1. Hirish, Herbert L. “*Essential Communication Strategies for Scientists, Engineers and Technology Professionals*”. Second Edition. New York: IEEE press, 2002
2. Anderson, Paul V. “*Technical Communication: A Reader-Centred Approach*”. Sixth Edition. Cengage Learning India Pvt. Ltd., New Delhi, Reprint 2010.
3. Strunk, William Jr. and White, E.B. “*The Elements of Style*” Alliyen & Bacon, New York, 1999.

ME654 PRODUCTION AND OPERATIONS MANGEMENT 3-0-0-3

Role of Production.- Production Control Information Flow - CAD/CAM and Production Control. Forecasting Demand forecasting – techniques – Moving average – Exponential smoothing . Techniques for causal analysis such as simple linear regression analysis and multiple regression analysis. Aggregate planning - Aggregate production planning – use of LPP formulation – Master production schedule –techniques – Bill of materials – MPS. Techniques for MRP – lot sizing-capacity planning and control – Scheduling capacity and materials. Lots Sizing Concepts Inventory management – continuous review and periodical review policies – models for determining economic order quantity with holding and shortage costs- backlogging-constrained inventory optimization models. Sequence Scheduling - Scheduling on single and multiple machines – Scheduling with multiple constraints – exact and heuristic techniques Line Balancing-A Key to Automation. Project Planning and Resource Constrained Scheduling. JIT and Lean systems Just-in-time and lean manufacturing systems.

TEXT BOOKS/ REFERENCES:

1. David D. Bedworth and James E. Bailey, “*Integrated Production, Control Systems: Management, Analysis and Design*”, Second Edition, Management Science, 1993.
2. Thomas E. Vollmann, “*Manufacturing Planning and Control for Supply Chain Management*”, Fifth Edition, McGraw Hill, 2005.
3. Evans, J. R., “*Production and Operations Management*”, Fifth Edition, West Publishing, 1998.
4. William J. Stevenson and Mehran Hojati, “*Production/Operations/Management*”, McGraw-Hill Ryerson Limited, 2001.
5. Chary,S.N., “*Production and Operations Management*”, Fourth Edition, Tata McGraw Hill,2009.

MA701 OPTIMIZATION THEORY 3-0-0-3

Introduction to Optimization: Engineering application of Optimization – Statement of an optimization problem - Optimal Problem formulation - Classification of optimization problems. Definition of Global and Local minima. Unconstrained Optimization: Optimality Conditions – Algorithms for univariate optimization – Algorithms for multivariate optimization – Convergence of algorithms - Engineering applications of unconstrained algorithms. Lagrange multiplier Theory & Duality: Lagrange multipliers - Kuhn-Tucker Optimality Conditions and sufficiency for convex problems – Lagrangian duality – Saddle point Conditions. Constrained Optimization: Optimality Conditions – Feasible direction methods – Frank-Wolfe algorithm – Gradient Projection – Active set methods - Penalty function methods – Constrained steepest descent method. Modern

methods of Optimization: Genetic Algorithms - Simulated Annealing – Tabu search - Ant Colony optimization – Particle Swarm Optimization – Neural-Network based Optimization – Fuzzy optimization techniques. Introduction to Multi-Objective optimization – Classical methods – Pareto Optimality – Use of evolutionary algorithms for solving Multi-Objective optimization problems. **Lab Practice:** Use of programming languages and Matlab to solve optimization problems.

TEXT BOOKS/ REFERENCES:

1. Kalyanmoy Deb, “*Optimization for Engineering Design Algorithms and Examples*”, Prentice Hall, 2000.
2. Rao, S. S., “*Engineering Optimization Theory and Practice*”, Fourth Edition, New Age International, 2009.
3. Saravanan. R., “*Manufacturing Optimization through Intelligent Techniques*”, Taylor and Francis, CRC Press, 2006.
4. Ravindran, Phillips and Solberg, “*Operations Research Principles and Practice*”, Wiley India, 2007.
5. Hadley, G., “*Non Linear and Dynamic Programming*”, Addison Wesley, 1964.

ME701

FINITE ELEMENT METHODS

3-0-0-3

Fundamentals of governing equations in Solid Mechanics and Heat Transfer. Strong form, weak form, Variational formulation, weighted residual method - Galerkin formulation, Formulation of the finite element equations - Element types - Basic and higher order elements- Coordinate systems. Finite elements in Solid Mechanics: analysis of trusses, beams and frames, Plane stress, plane strain and axisymmetric elements, Plate and shell elements.- Isoperimetric formulation. Finite elements in Heat Transfer: Formulations and solution procedures in one-dimensional and two-dimensional problems. 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:

1. Rao, S. S., “*The Finite Element Method in Engineering*”, Fourth Edition, Elsevier, 2007.
2. Jacob Fish and Ted Belytschko, “*A First Course in Finite Elements*”, Wiley Inter Science, 2007.
3. David V. Hutton, “*Fundamentals of Finite Element Analysis*”, McGraw Hill, 2005.
4. Daryl L. Logan, “*A First Course in the Finite Element Method*”, Fourth Edition, Cengage Learning, 2007
5. Zienkiewicz, O.C., Taylor, R.L., and Zhu, J.Z., “*The Finite Element Methods, Vol.1- The Basic Formulation and Linear Problems*”, Sixth Edition, Butterworth Heinemann, 2005.

Characteristics and Tribology of surfaces: Classification of surfaces and properties. Protection and modification. Friction of solids and wear. Surface Treatment and Coating: Heat and diffusion techniques. Physical/chemical vapor 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. Process Modelling: Diffusion phenomenon and equation. Effects of phase transformation. Simulation of surface modification processes. Solutions for practical problems. Characterization: Novelty of composition and microstructure - post irradiation characterization and testing/evaluation of surface-properties - structure-property correlation. Failure mechanisms.

TEXT BOOKS/ REFERENCES:

1. Griffiths, B., "*Manufacturing Surface Technology*", Taylor and Francis, 2001.
2. Davis, J. R., "*Surface Engineering for Corrosion and Wear Resistance*", Maney, 2001.
3. Halling, J., "*Principles of Tribology*", Macmillan, 1992.
4. Ohring, M., "*The Materials Science of Thin Films*", Academic Press Inc., 2005.

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:

1. Douglas C. Montgomery, "*Design and Analysis of Experiments*", Seventh Edition, Wiley, 2010.
2. Jiju Antony, "*Design of Experiments for Engineers and Scientists*", Elsevier, 2003.
3. Larry B. Barrentine, "*An Introduction to Design of Experiments: A Simplified Approach*", ASQ Quality Press, 1999.
4. Paul G Mathews, "*Design of Experiments with MINITAB*", ASQ Quality Press, 2003.
5. Mark J. Anderson and Patrick J. Whitcomb, "*DOE Simplified: Practical Tools for Effective Experimentation*", Second Edition, Productivity Press, 2007.

Description and application of advanced welding processes: GTA, GMA, friction stir, electron and laser beam, plasma arc and electro-slag welding.

Solidification behaviour in fusion welding: weld pool shape and columnar grain structures, solidification microstructures, solute redistribution and peritectic solidification. Grain growth in welds. Solid-state transformations in welds. Weldability of Al, Fe, Cu, Ti based alloys.

Welding heat sources: types and characteristics. Modelling of heat distribution: stationary and moving heat sources. Modelling of heat flow during welding and prediction of thermal history: steady state, transient and pseudo-steady state heat conduction. Prediction of cooling rate and its effects on microstructure and mechanical properties.

Welding defects. Residual stress and distortion in welding. Numerical analysis of residual stresses in welding processes. Control of distortion.

Codes, Standards and Case Studies.

TEXT BOOKS/ REFERENCES

1. Grong, O, “*Metallurgical Modelling of Welding*”, Second Edition, The Institute of Materials, 1997.
2. Kou, S., “*Welding Metallurgy*”, Second Edition, John Wiley Publications, New York, 2003.
3. Metals Handbook, Vol. 6, “*Welding, Brazing and Soldering*”, ASM International, Metals Park, Ohio, 1988.

Embedded system concepts, sensors, actuators and real-time systems, embedded hardware and software, application of microcontrollers in manufacturing process control. Real-Time process monitoring and control in manufacturing processes: machining, metal forming and welding, Roles of Sensors in Manufacturing and Application Range, Sensors for machine tools and robots, workpieces and process monitoring, Classification and types, mechatronics systems in Computer Aided and Integrated Manufacturing Systems, Industrial Networks in manufacturing: CAN and Ethernet based networks, Networking of Sensors and control systems in manufacturing, Computer communications: layers and protocols, Flexible manufacturing systems: robot control through vision sensors, Real-time embedded control in distributed networks, Applications of Industrial Networks for Control, Diagnostics and Safety

TEXT BOOKS/ REFERENCES:

1. Richard Zurawski, “*Embedded Systems Handbook: Networked Embedded Systems*”, Second Edition, CRC Press, 2009.
2. Dogan Ibrahim, “*Microcontroller Based Applied Digital Control*”, John Wiley and Sons, 2006.
3. Sabrie Soloman, “*Sensors and Control Systems in Manufacturing*”, Second Edition, McGraw Hill, 2010.
4. Cornelius T. Leondes, “*Computer Aided and Integrated Manufacturing Systems- Volume 5: Manufacturing Processes*”, World Scientific Publishing, 2003.

5. Jan Wikander and Bertil Svensson, “*Real-Time Systems in Mechatronic Applications*”, Kluwer Academic Publishers, 1998.

ME706 ADVANCES IN MANUFACTURING TECHNOLOGY 3-0-0-3

Precision engineering – concepts and significance – micro fabrication – types - top down – bottom up approaches –Micro Electro-Mechanical Systems (MEMS) - LIGA process – lithography steps – X ray lithography – masks – mask materials. Micromachining – theory of micromachining – types – concepts – tools used in micromachining – micro EDM – micro wire cut EDM – micro ECM – micro EDG - abrasive jet micromachining - water jet micromachining. Laser based micromachining – types of Lasers – diode, excimer and Ti: Sapphire lasers – nanosecond pulse micro fabrications – shielding gas. Micro Metrology- Scanning Electron Microscopy, optical microscopy, atomic force microscope, molecular measuring machine, Micro-CMM, Transmission electron microscope- principles- applications. Applications - automotives and home electronics- Integrated Microsystems- Microsensors, Microactuators, Microaccelerometers and Gyroscope - medical engineering-bio sensors. Nano-engineering –concepts – significance and applications – nano surface generation – diamond turning – ELID grinding – electron beam nano fabrication.

TEXT BOOKS/ REFERENCES:

1. Marc J. Madou, “*Fundamentals of Microfabrication*”, Second Edition, CRC Press, 2002.
2. Jain, V. K., “*Introduction to Micromachining*”, Narosa Publishing House, 2010.
3. Tai – Ran Hsu, “*MEMS and Microsystems: Design and Manufacturing*”, Tata McGraw Hill, 2002.
4. Mohamed Gad-el-Hak, “*The MEMS Handbook*”, CRC Press, 2002.

ME707 LOGISTICS AND SUPPLY CHAIN MANAGEMENT 3-0-0-3

Introduction: Introduction to SCM-the complexity and key issues in SCM – Location strategy – facility location decisions – single facility and multiple location models. Logistics: Logistics Network Configuration – data collection-model and data validation-solution techniques-network configuration DSS – Transport strategy – Service choices: single service and inter modal services – vehicle routing and scheduling models – travelling salesman problems – exact and heuristic methods. Inventory strategy: Inventory Management and risk pooling-managing inventory in the SC. The value of information - bullwhip effect - lead time reduction. Supply chain integration: Supply chain integration-distributed strategies-push versus pull systems. Distribution Requirements planning – DRP and demand forecasting, DRP and master production scheduling. DRP techniques – time-phased order point – managing variations in DRP – safety stock determination-Strategic alliances-third party logistics-distribution integration. Issues in SCM: Procurement and outsourcing strategies – framework of e-procurement. International issues in SCM-regional differences in logistics. Coordinated product and supply chain design-customer value and SCM.

TEXT BOOKS/ REFERENCES:

1. David Simchi-Levi and Philip Kaminsky, “*Designing and Managing the Supply Chain: Concepts, Strategies, and Cases*”, McGraw Hill, 2002.
2. Martin Christopher, “*Logistics and Supply Chain Management: Strategies for Reducing Cost and Improving Service*”, Prentice Hall, 1999.
3. Ronald Ballou, “*Business Logistics / Supply Chain Management*”, Pearson Education, 2003.
4. Thomas E. Vollmann, Willan L. Bery, Robert Jacobs, F., and David Clay Bark, “*Manufacturing Planning and Control for Supply Chain Management*”, Fifth Edition, McGraw Hill, 2005.

ME708**COMPOSITE MATERIALS AND PROCESSING****3-0-0-3**

Types and forms of reinforcement and their properties. Pre-fabricated forms. Selection of matrices: physical and mechanical properties. Bonding mechanisms. Types of reinforcement distributions: uniform, gradient and surface. Factors in composite design. Structure-property relationships. Models of various materials properties of composites: density, modulus, strength, specific heat, coefficient of thermal expansion, thermal conductivity and diffusivity, electrical conductivity and dielectric constant. Isotropic and anisotropic properties.

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. Review of case studies.

TEXT BOOKS/ REFERENCES:

1. Clyne, T. W. and Withers, P. J., “*An Introduction to Metal Matrix Composites*”, Cambridge University Press, 1993.
2. Matthews, F. L. and Rawlings, R. D., “*Composite Materials: Engineering and Science*”, Chapman and Hall, London, 1994.
3. Suresh, S., Martensen, A., and Needleman, A., “*Fundamentals of Metal Matrix Composites*”, Butterworth Heinemann, 1993.
4. Kainer, K.U., “*Metal Matrix Composites: Custom-Made Materials for Automotive and Aerospace Engineering*”, Wiley-VCH, 2006.
5. Chawla, N. and Chawla. K. K., “*Metal Matrix Composites*”, Springer, 2006.

ME709**PRODUCT LIFECYCLE MANAGEMENT****3-0-0-3**

Introduction to Product life cycle - PLM- PDM concepts -present market constraints - need for collaboration – Object oriented programming concepts - internet and developments in server - client computing. Components of a typical PLM / PDM setup - hardware and software - document management - creation and viewing of parts and documents- version control -case studies. Configuration management: Base lines - product structure - configuration management – Effectivity - case studies.

Creation of projects and roles - life cycle of a product- life cycle management - automating information flow-workflows - creation of work flow templates -life cycle - work flow integration - case studies. Change management: Change issue- change request-change investigation- change proposal - change activity - case studies. Generic products

and variants: Data Management Systems for FEA data - Product configuration - comparison between sales configuration and product configuration -generic product modeling in configuration model - use of order generator for variant creation-registering of variants in product register-case studies. Implementation issues and best practices.

TEXT BOOKS/ REFERENCES:

1. Kevin Otto and Kristin Wood, "*Product Design*", Pearson, 2001.
2. Daniel Amor, "*The E-Business Revolution*", Prentice Hall, 2000.
3. David Bed Worth, Mark Henderson, and Phillip Wolfe, "*Computer Integrated Design and Manufacturing*", McGraw Hill, 1991.
4. Terry Quatrain., "*Visual Modeling with Rational Rose and UML*", Addison Wesley, 1998.
5. Antti Saaksvuori and Anselmi Immonen, "*Product Life Cycle Management*", Second Edition, Springer, 2005.

ME710

TOOL ENGINEERING AND DESIGN

3-0-0-3

Cutting tools: Design of single point tool-strength and rigidity consideration, Design of twist drill, milling cutters, reamers and broaches. Jigs & Fixtures: Tolerance analysis and procedure of designing. The economic calculations, location of the work piece, degree of freedom, references surfaces, resting components, fixture elements for surface concentric and radial locations – Clamping of the workpiece, review of cutting forces, principles and methods of clamping. Quick clamping devices, standards. Guiding elements for tools, jig bushes, standards – indexing methods – standards in design of Jigs/Fixtures/Accessories for Drilling, Milling, Turning, Broaching, and Grinding. Press tool design: Introduction terminology shearing dies- types of dies – analysis process shearing clearance –size and tolerances of die opening and punch – force, power, energy in shearing – loading center, shearing with inclined edges – strip layouts, economical stock. Design of Compound and progressive dies. Design of bending, drawing and forming dies- blank development, strain factor, calculation of force, construction of drawing and drawing dies.

TEXT BOOKS/ REFERENCES:

1. Cyril Donaldson and Donaldson Mn, "*Tool Design*", Third Edition, Tata McGraw-Hill Education, 2001.
2. Edward G. Hoffman, "*Jig and Fixture Design*", Cengage Learning, 2004.
3. Paul D. Q. Campbell, "*Basic Fixture Design*", Industrial Press Inc., 1994.

ME711

ADVANCES IN PROCESS TECHNOLOGY

3-0-0-3

Selected topics on recent advances in various areas of manufacturing process technologies-casting, welding, forming, electroforming, melt spinning, moulding, surface modification by 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, composite processing and rapid prototyping. New materials including carbon, silicon carbide and alumina fibres and their manufacturing methods. Case studies.

TEXT BOOKS/ REFERENCES:

1. Griffiths B., “*Manufacturing Surface Technology*”, Taylor and Francis, 2001.
2. Schwartz M., “*New Materials, Processes, and Methods Technology*”, Taylor and Francis, 2006.
3. Yu K.O., “*Modeling for Casting and Solidification Processing*”, Marcel Dekker, 2002.
4. Grong O, “*Metallurgical Modeling of Welding*”, Second Edition, The Institute of Materials, 1997.
5. Kainer K.U., “*Metal Matrix Composites: Custom-Made Materials for Automotive and Aerospace Engineering*”, Wiley-VCH, 2006.

ME712**RELIABILITY ENGINEERING****3-0-0-3**

Concept and Definition of reliability (reliability mathematics)-Failure distributions, hazard models – exponential, Rayleigh, Weibull, Normal and Lognormal distributions - MTTF, MTBF. Reliability of systems – series and parallel configurations - Reliability improvement, redundancy, k-out-of-n system -Reliability of complex configurations-Reliability of three-state devices – Markov analysis-Physical reliability models – random stress and random strength-Design for reliability-Reliability allocation, derating-Maintainability-Design for maintainability-Availability-Maintenance and space provisioning. Failure data analysis-Reliability Testing-Identifying failure distributions-parameter estimation.

TEXT BOOKS/ REFERENCES:

1. Charles Ebeling, “*An introduction to Reliability and Maintainability Engineering*”, Tata McGraw Hill, 2000.
2. Lewis E. E., “*Introduction to Reliability Engineering*”, Second Edition, John Wiley and Sons, 1995.
3. Rao S. S., “*Reliability Based Design*”, McGraw Hill, 1992.
4. Barlow R. E., Prosolan F., and Hunter L. C., “*Mathematical Theory of Reliability*”, John Wiley, 1965.
5. Srinath L.S., “*Mechanical Reliability*”, East-West Press,2002.

ME713**FINANCIAL MANAGEMENT****3-0-0-3**

The finance function – Corporate objectives – Corporate Governance Capital markets, market efficiency and ratio analysis – Business Finance- Capital Markets. An overview of investment appraisal methods – Payback Period – ARR – NPV – IRR methods-Profitability Index and capital rationing- Discounted Payback method Investment appraisal: applications and risk. Project Cash flows- Capital Investment decisions- Risks Sources of long-term finance: equity finance- new issues – rights issues – scrip issues-stock splits- scrip dividends- share repurchases – preference shares . Sources of long-term finance: debt finance, hybrid finance and leasing Dividend policy - The cost of capital and capital structure- –Avg Vs Marginal Cost of Capital. Working capital management. – policies- cash conversion cycles- overtrading - Mergers and takeovers – Strategic and tactical Issues. Risk management- Internal and External risk management – interest and exchange rate risk- International investment decisions- International trade- political risk-foreign investment decisions

Entrepreneurial Finance for New and Emerging Businesses – Identifying and Financing a start up – Measuring and Evaluating financial performance – Venture Capital.

TEXT BOOKS/ REFERENCES:

1. Denzil Watson and Antony Head, “*Corporate Finance Principles and Practice*”, Pearson Education, 2002.
2. Terry S. Manes, “*Introduction to Corporate Finance*”, McGraw Hill, 1998.
3. James C. Vanhorne and John M. Wachowilz, “*Fundamentals of Financial Management*”, Prentice Hall, 1996.
4. Jae K. Shim and Joel G. Siegel, “*Financial Management*”, Barron’s Educational Series, 2008.
5. Cornwall, Jeffrey R, Vang, David O and Hartman, Jean M, “*Entrepreneurial Financial Management: An Applied Approach*”, Yes Dee Publishing, Chennai, 2009.
6. J. Leach and Ronald Melicher, “*Entrepreneurial Finance*”, Fourth Edition, South-western Cengage Learning, USA, 2012.

ME714 COMPUTER AIDED PRODUCT DEVELOPMENT 3-0-0-3

Introduction to New Product design – Creativity and Innovation - concept design – parametric sketching – constraints- Feature based modelling - synchronous technology – contemporary software – Kernel and graphics engine – Hardware requirements - data exchange formats. Computers in Design — Assembly modelling – creation of BOM – issues in large assemblies - associative features – Sheet metal components, nesting and development – plastic parts with draft and shrinkage allowance – Reverse engineering of components – tolerance analysis – check for interferences and mass property calculations Computers applications in tool design – mould design – jigs and fixtures design – mechanism design and analysis – Rapid tooling – Computer aided inspection. Computers in Design Productivity – customisation using various software like visual basic, pro/program, script, LISP etc. to write applications like design of shafts, gears etc. Managing product design data – 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.

TEXT BOOKS/ REFERENCES:

1. William M. Neumann and Robert Sproul, “*Principles of Computer Graphics*”, McGraw Hill, 1989.
2. Ibrahim Zeid, “*CAD/CAM – Theory and Practice*”, McGraw Hill, 1998.
3. Rao P. N., “*CAD/CAM: Principles and Applications*”, Second Edition, Tata McGraw Hill, 2004.
4. Schlechtendahl E. G., “*CAD – Data Transfer for Solid Models*”, Springer Verlag, 1989.
5. Donald Hearn and Pauline Baker M., “*Computer Graphics*”, Prentice Hall, 1992.

Basic concepts in Quality Engineering: definitions, approaches and relevance to organizational excellence. Quality and Competitiveness. Product quality control: Acceptance sampling methods- single, multiple and sequential sampling plans; Recent developments in inspection methods. Statistical Process Control: Process evaluation and control by control charts: x-bar and R-bar charts, Moving Average and Moving Range Charts, Charts for Individuals, Median and Range Charts. Control Charts for Attributes - Non-conforming, Non-conformities (defects). Process capability studies: Various indices and approaches; use of Nomographs; Discussions on capabilities of Process. Quality costs-Quality measurement. Total Quality Management perspective, methodologies and procedures; Roadmap to TQM, ISO 9000, KAIZEN, Quality Circles, Models for organizational excellence. Quality Function Deployment, Quality Cost Systems and Quality Policy Deployment. Implementation of TQM and the management of change. 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 BOOKS/ REFERENCES:

1. Douglas C. Montgomery, “*Design and Analysis of Experiments*”, Seventh Edition, Wiley, 2010.
2. Juran J.M., “*Quality Control by Design*”, The Free Press, 1992.
3. Mitra A., “*Fundamentals of Quality Control and Improvement*”, Second Edition, PHI, 2005.
4. Evans J.R. and Lindsay W.M., “*The Management and Control of Quality*”, Thomson, 2005.
5. Wadsworth H.M., Stephens K.S. and Godfrey A.B., “*Modern Methods for Quality Control and Improvement*”, John Wiley & Sons, 2004.

Classification of manufacturing processes, Different Manufacturing Systems, Introduction to additive manufacturing, Need for the compression in product development, history of RP systems, survey of applications, growth of RP industry, classification of RP systems. Process Technology and Comparative study of :- Stereolithography (SL) with photo-polymerization, process details, data files. Fused Deposition Modeling –process parameters, path generation, and applications. Selective Laser Sintering-data preparation for SLS, process parameters, applications. Laminated Object Manufacturing, Solid Ground Curing, Laser Engineered Net Shaping. Concept Modelers: Thermo-jet printer, 3-D printer. Software for RP: Programming in RP, Modeling, Slicing, Internal Hatching, Surface Skin Fills, Support Structure. Rapid Tooling: soft and hard tooling- Indirect rapid tooling - silicone rubber tooling, aluminium filled epoxy tooling, spray metal tooling, etc., direct rapid tooling - direct AIM, quick cast process, copper polyamide, rapid tool, DMILS, prometal, sand casting tooling, laminate tooling, soft tooling Vs hard tooling. Process Optimization: Factors influencing accuracy, data

preparation errors, part building errors, errors in finishing, influence of part build orientation

TEXT BOOKS/ REFERENCES:

1. Andrews Gebhardt, "*Rapid Prototyping*", Hanser Publishers, 2003.
2. C. K. Chua, K. F. Leong, "*Rapid Prototyping- Principles and Applications*", Third Edition, World Scientific Publishing, 2010.
3. Paul F Jacobs, "*Stereolithography and other RP&M Technologies: from Rapid Prototyping to Rapid Tooling*", Society of Manufacturing Engineers and the Rapid Prototyping Association, New York, 1996.