

*Full Scheme and Syllabi*

**M Tech**  
**In**  
**Manufacturing Technology**  
**(Full Time)**  
**2014 Onwards**



***Department of Industrial Engineering***  
**Dr B R AMBEDKAR NATIONAL INSTITUTE OF**  
**TECHNOLOGY**  
**JALANDHAR, 144011 India**

## Course Structure and Scheme for M.Tech Full Time Programme in Manufacturing Technology

Maximum Credits = 65

### SEMESTER - I

Course Code	Course Title	Hrs/week			Credits
		L	T	P	
IE-501	Casting and Welding Technology	3	0	0	3
IE-503	Advanced Manufacturing and CAD	3	0	0	3
IE-505	Tool Engineering and Mechanics of Cutting	3	0	0	3
IE-507	Simulation & Modeling	3	0	0	3
IE-***	Elective - I	3	0	0	3
IE-***	Elective - II	3	0	0	3
IE-509	Advanced Manufacturing and CAD	0	0	3	2
IE-511	Casting and Welding Laboratory	0	0	3	2
	Total	18	0	6	22

### SEMESTER - II

Course Code	Course Title	Hrs/week			Credits
		L	T	P	
IE-502	CIM & Robotics	3	0	0	3
IE-504	Mechanics of Metal Forming	3	0	0	3
IE-506	Operations Management	3	0	0	3
IE-***	Elective - III	3	0	0	3
IE-***	Elective - IV	3	0	0	3
IE-***	Elective - V	3	0	0	3
IE-510	CIM and Robotics Laboratory	0	0	3	2
IE-512	Metal Cutting and Forming Laboratory	0	0	3	2
	Total	18	0	6	22

### SEMESTER - III

Course Code	Course Title	Hrs/week			Credits
		L	T	P	
IE-519	Seminar	0	0	6	3
IE-520	Dissertation (Phase-I)**	0	0	12	6
	Total	0	0	18	9

**SEMESTER - IV**

Course Code	Course Title	Hrs/week			Credits
		L	T	P	
IE-520	Dissertation (Phase-II)**	0	0	24	12
	Total	0	0	24	12

**LIST OF ELECTIVES**

Sr. No.	Code	Course Name
1.	IE-521	Design for Manufacturing and Assembly
2.	IE-522	Advanced Materials and Metallurgy
3.	IE-523	Networks and Project Management
4.	IE-524	Application of Control Engineering in Manufacturing
5.	IE-525	Management Information Systems
6.	IE-526	Non-conventional Machining Techniques
7.	IE-527	Low Cost Automation
8.	IE-528	Logistics and Supply Chain Management
9.	IE-529	Machine Tool Design
10.	IE-530	Quality Management
11.	IE-531	Environment Management Systems
12.	IE-532	Finite Element Analysis in Manufacturing
13.	IE-533	Statistics for Research
14.	IE-534	Advanced Operations Research
15.	IE-535	Soft Computing Techniques
16.	IE-536	Reliability and Maintenance Engineering
17.	IE-537	Product Analysis and Cost Optimization
18.	IE-538	Value Engineering
19.	IE-539	Inventory Management Systems
20.	IE-540	System Dynamics
21.	IE-541	Strategic Management
21.	IE-542	Advanced Optimization in Manufacturing
22.	IE-543	Research Methodology
23.	IE-544	Change Management
24.	IE-545	Mechanics of Metal Cutting
25.	IE-549	Marketing Management
26.	IE-552	Financial Management and Accounting
27.	IE-553	Work System Design
28.	IE-560	Occupational Health and Safety Management
29.	IE-575	Advanced Manufacturing Practices
30.	IE-576	Fracture and Fatigue
31.	IE-577	Micro Electro Mechanical System
32.	IE-578	Human Factor Engineering
33.	IE-579	Energy and Environment

**Casting Processes:** Core making processes - design for economical sand molding - Designing for economical coring - influence of shapes on core requirements - sections - support for sand cores principles of gating and riser design for sand casting. Use of CAD in the design of gating and risering systems. Principles, technology and scope of shell molding, investment casting - permanent mould - pressure die casting - centrifugal casting - continuous casting, Recent developments: Low pressure die casting, squeeze casting process -non ferrous casting, techniques for the production of defect free casting

**Welding Metallurgy, Weldability and Welding Design:** Heat flow in welding - Metallurgical transformations in and around weldment - Implications of cooling rates, Weld ability criteria and its evaluations; Metals considered in details; C and C-Mn steels, HSLA steels. Design of weldments - Joints design and their implications under various processes - Residual stresses and distortion.

**Welding Processes:** Detailed background, process characteristics, consumables selection, parameter evaluations and applications to materials and utilities of processes: MMAW, GAS shielded arc welding, SAW, ESW, PAW, Stud Welding, Resistance Welding, Solid state welding and radiant energy welding processes. Melting and quality control of various types of steels and non-ferrous alloys in foundries. Casting defects and remedies - inspection and testing of castings. Manufacturing of grey C.I, Malleable iron, and S.G iron.

**Inspection and Testing of Welds:** Different types of cracks and their mechanisms, causes, cure and method of detection, Destructive tests - Types of defects in welding - process wise and severity wise. Non-destructive testing techniques, special features, comparisons and utility values; Newer NDT techniques and their applications.

### Recommended Books

1. Khanna,O.P., A Text book of welding Technology, Dhanpat Rai & Sons, 1997.
2. American Welding Society, Welding Handbook, Section I to V" 8th Edition, 1996.
3. Nadkarni,S.V., Modern Arc welding techniques handbook, Oxford IBH, 1988.
4. Heine,R.W.,Lopper,C.R. & Rosenthal,P.C., Principles of Metal casting, Tata McGraw Hill Pub., 1986.
5. Jain,P.L., Principles of Foundry Technology, Tata McGraw Hill Pub., 1985.

**Role of Computer Graphics in CAD/CAM:** Configuration of graphic workstations, Fundamental of 2D graphics, Menu design and Graphical User Interfaces (GUI), Customization and Parametric programming.

Vector representation of geometric entities, Homogeneous coordinate systems, Geometric transformations. Planar and space curve design analytical and synthetic approaches, Parametric and implicit equations, Modelling of biparametric freedom surfaces coons, Bezier, B-spline and NURBS surface patches, Surface manipulation techniques.

**CNC Machines:** Types, classification, File formats, Controllers, Distributed NC, hierarchical control, Issues in File Transfer and Integration, Tool on CNC, Fixtures on CNC. Material handling and storage systems like Robots, AGVs, AS/RS etc.

**Development for Tool and Material Handling System:** Automation Inspection Systems, use of CMMs, Communication Systems, Links in the network., Computer Control Systems.

**Agile manufacturing:** Lean manufacturing - Rapid prototyping - Virtual Reality, Mushy state processing; application of Artificial Neural Network in manufacturing- Ductile machining of brittle materials and Brittle Machining of Ductile material - Machining of composite materials.

**Precision Engineering:** its concepts and significance - precision engineering in Development of machine tools. Non-traditional machining process in micro machining - stereo lithography - epitaxy methods - technology - manufacturing of integrated circuits.

**Mechatronics Approach:** micro sensors-micro actuators - examples of mechatronics systems from robotics, manufacturing machine diagnostic.

### Recommended Books

1. Serope Kalpakjian, Manufacturing Process for Engineering Materials, Addison - Wesley Publishing Company, 1997.
2. Faux, I. D. and Pratt, M. J., Computational Geometry for Design and Manufacture, John Wiley and Sons, NY, 1979.
3. Mortenson, M. E., Geometric Modelling, John Wiley and Sons, NY, 1991.
4. P.G.Ranky, The Design and Operation of FMS, IFS Publ. 1983.
5. R. Stover, An analysis of CAD/CAM application with Introduction to CIM Prentice Hall Inc., Englewood Cliffs, NY.

Influence of tooling on quality and productivity. Requirement of tooling for flexible, small lot production with constraints on lead time.

**Jigs and fixture** – Basic principles of locating, clamping. Development of fixture using locating, clamping, indexing tool setting elements. Force analysis – Standardization of elements. Illustrative examples of machining, welding, assembly and inspection fixtures. Design of special toolings (form cutters, broaches, etc). Tooling for CNC, Development of modular fixtures and tools, flexitools, etc. Innovative concepts like tooling for fragile parts, plastics for tooling, etc.

**Tooling for press operations** - Cutting action in punch and die operations, die clearance, cutting forces, methods of reducing cutting forces, minimum diameter of piercing, blanking die design, piercing die design, bending dies, drawing dies. Open & closed die forgings, Principles of die design for forging operations, die material and processes of manufacture of dies, die maintenance, die block dimensions, Selection of forging equipments, die inserts, stock size for closed and open die forging.

**Mechanics of Cutting** - Various methods of metal removal, Mechanics of orthogonal cutting, nature of contact between chip and tool, stress distribution at chip-tool interface, controlled contact tools, Mechanics of oblique cutting, Thermal aspects of metal cutting, Cutting fluids, method of selection of fluids, Dry cutting, Tool wear, Wear theories, experimental methods, Tool life, Machinability.

#### **Recommended Books**

1. Grant Hiram E, Jigs & Fixtures, Tata McGraw Hill Publishing Company, 1994.
2. Wilson F. W., Tool Engineers Handbook, Tata McGraw Hill, New Delhi, 1968.
3. Donaldson Cyril, Tool Design, Tata McGraw Hill Publishing Company Limited, 1997.
4. Sen and Bhattacharya, Principles of Machine Tools, New Central Book Agency.
5. Arshimov and Alekree, Metal Cutting Theory and Cutting Tool Design, MIR Publications.

**Introduction:** Concept of system and environment, components of a system, discrete and continuous systems, linear and non-linear systems, stochastic activities, areas of applications of simulation

**Physical modeling:** Models of a system, types of models, stochastic and dynamic models, principles used in modeling, guidelines for determining the level of model details, techniques for increasing model validity and credibility

**Probability concepts:** Random variables and their properties, discrete and continuous probability functions, Poisson processes, empirical distributions, random numbers, random numbers and random variate generation.

**System simulation:** Techniques of simulation, Monte Carlo method, experimental nature of simulation, numerical computation techniques, output data analysis for single system, comparing alternative system configurations, statistical procedure for comparing real world observations with simulation data.

**Simulation of queuing systems:** introduction, components of a waiting line system, stationary and time dependent queues, costs of customer waiting time and idle capacity, time flow mechanism, long run measure of performance of queuing systems, study state behavior, of finite and infinite population models.

**Design of simulation experiments:** verification and validation of simulation, validation of models, design of simulation experiment, length of simulation run, replication of runs, batch means, elimination of initial bias, statistical independence of observations, variance reduction techniques,

**Case studies:** Simulation of various inventory systems, simulation of PERT, simulation of manufacturing and material handling systems

#### Recommended Books

1. J. banks, John S Carson,—Discrete Event System Simulation, Prentice Hall Inc.
2. Averill M Law, and W D Kelton, Simulation Modeling and Analysis, McGraw Hill Inc.
3. J. Schwarzenbach, and K.F. Gill,—System Modeling and Control, Edward Arnold.
4. Allan Carrie, Simulation of Manufacturing Systems, John Wiley and Sons.
5. Viswanadhan, and Narahari, Performance modeling of Automated Manufacturing Systems, Prentice Hall Inc.

Creating component drawing and making sub assemblies using PRO/Engineer, UNIGRAPHICS and IDEAS choosing from the following components.

1. Steam stop valve
2. Tail stock
3. Plummer block
4. Check valve
5. Flange Coupling
6. Universal Coupling
7. Stuffing Box
8. Connecting Rod

Programming on CNC lathe and milling, demonstrating linear interpolation, circular interpolation, canned cycles.

Demonstration on EDM/ Wire cut machines

Analyses of cutting tool wear monitoring systems.

Analysis of micro-machining processes,

Reverse engineering systems using RPT



Casting and Welding Laboratory would include following experiments:

1. To analyze the variation in process parameters such as welding current, voltage, wire feed rate etc. on different output parameters for Tungsten Inert Gas welding System.
2. To study and analyse the process parameters such as welding current, voltage, wire feed rate etc. on different output parameters for Metal Inert Gas welding System.
3. To study and analyse the process parameters such as welding current, voltage, wire feed rate etc. on different output parameters for Submerged Arc Welding System.
4. To study and analyse the process parameters for Plasma welding and cutting system.
5. To study and analyse the process parameters for Spot welding unit.
6. To prepare a sample of casting by varying process parameters using Injection Molding Machine.
7. To study and analyse the variation in microstructure of casting sample by varying process parameters for sand casting process.

**Design Automation: CAD:** Introduction to CAD systems, general system operations, CAD classification: hardware problems, CAD classification : software, application of CAD to manufacturing systems

**Production Process Machines and Systems:** Material and machine processes, flexible manufacturing, fixed high volume automation, industrial robots, automated material handling, automatic guided vehicles

**Fundamentals of Robotics:** Definition of a robot, types and technology levels of robots, classification of robots, parts of a robot, applications.

**Dynamic modeling of Rigid Manipulators:** Kinematics modeling of manipulator arms, Denavit Hartenberg notations, inverse kinematics, kinematics modeling of instantaneous motions, inverse instantaneous kinematics, Euler – Bernoulli equations for deriving the dynamics, Lagrangian formulation of manipulator dynamics, inverse dynamics, trajectory planning.

**Conventional Sensors and Actuators for Robots:** Linear and rotary encoders, resolvers, dynamic modeling of servo motors and stepper motors.

**Smart Sensors and Actuators for Robots:** Definition of a sensor, fiber optic sensors, definition of an actuator, intelligent actuators and smart actuators.

**Control of Robots:** Open loop control and closed loop control of robot manipulators, open loop control by computed torque method, closed loop control for disturbance rejection and trajectory execution, individual joint PID control of single and multilink manipulators.

#### **Recommended Books**

1. Asada and Slotine, Dynamics and control of robot manipulators , Wiley, New York.
2. JS Rao , Advanced theory of vibrations, Wiley Eastern New Delhi.
3. James a Rehg, Henry W. Kraebbatr, Computer Integrated Manufacturing, Pearson Education Asia, 2<sup>nd</sup> edition
4. Groover M P , Automation, Production Systems & CIMII Pearson Education Asia, 2<sup>nd</sup> edition
5. AK Sawhney,A course in Mechanical Measurements and instrumentation, Dhanpat Rai publication
6. H. Janocha , Adaptronics and Smart Structures, Springer, New York
7. JJ Craige, Introduction to Robotics, Pearson Education, New Delhi.

Technological advances in metal forming processes- forging, rolling, extrusion, wire drawing and sheet metal forming, Design of roll pass and rolling schedules, Description of typical cold rolling and hot rolling mill plants, extrusion and wire drawing, Automation in metal forming processes, Recent developments in forming equipment, Advances in sheet metal forming, Unconventional forming processes like Hydrostatic extrusion, High energy rate forming processes, Hydro-forming of sheets and tubes, Powder forming.

Stress-strain relations in elastic and plastic deformations, Yield criteria for ductile metals, Work hardening and Anisotropy in yielding, Elements of theory of plasticity, Formulation of plastic deformation problems, Application of theory of plasticity for solving metal forming problems using slab method, Upper and lower bound methods, slip line field theory, Effect of temperature and strain rate in metal working, Friction and lubrication in cold and hot working, Technology and Analysis of important metal forming processes–Forging, Rolling, Extrusion, Wire Drawing, Sheet metal forming processes like Deep drawing, Stretch forming, Bending, Introduction to Finite Element Analysis of metal forming processes.

#### **Recommended Books**

1. William F. Hosford & Robert M. Caddel, Metal forming, (Mechanics & Metallurgy), Prentice Hall Publishing Co., 1990.
2. Rao P.N, Manufacturing Technology, TMH Ltd., 1998. (Revised Edition).
3. Oscar Hoffman and George Sachs, Introduction to the theory of plasticity for Engineers, McGrawhill Book Company Inc.
4. Johnson and Miller, Engineering Plasticity, New York: Halsted, 1983
5. Nagpal. G.R., Metal forming processes, Khanna Publishers, Delhi, 1998.

**Operations Management:** The operations function in the organization, Historical evolution, System's view of operations, Managing sub-systems of operations, Strategic role of operations, Trends in operations management

**Forecasting:** Forecasting in operations, Useful forecasting models, selection of forecasting model, Behavioral dimension of forecasting, role of computers in forecasting

**Work System Design:** - Method study, objectives, step by step procedure, Charts and Diagrams for recording the data, principles of motion economy, various work measurement techniques i.e. work sampling, stop watch time study, Rating, methods of rating, allowances and their types, standard time, incentive plans, numerical problems

**Facilities planning and design:** - Concept of facility, need for location decisions, steps in location study, subjective, qualitative and quantitative techniques for location selection, types of layouts, plant layout factors, layout design procedure

**Inventory management:** - Functions of inventory, selective inventory management, Inventory costs, Wilson's lot size model, production rate model, quantity discount models, functions of stores, stock verification, stores accounting

**Just in time manufacturing:-** JIT philosophy, Waste, types of manufacturing wastes, characteristics of JIT environment, supplier partnership, Pull system, Kanban system, Role of inventory reduction in system improvement, MRP

**Capacity planning:** - Definition, process of capacity planning, predicting future capacity requirements, generation and evaluation of alternate capacity plans

#### Recommended Books

1. Evert E. Adam, Ronald J Ebert, Production and Operations Management, Prentice Hall of India, 5<sup>th</sup> edition.
2. J R Tony Arnold, Chapman Stephen N., Introduction to Materials Management, Pearson Education Asia, 4<sup>th</sup> edition.
3. Buffa , Modern Production/ Operations Management, Wiley Eastern New York (1999)
4. Ray Wild , Operation Management, Thomson press, 6<sup>th</sup> edition
5. Krejwski L J , Ritzman L P , Operation Management, Pearson Education Asia, 6<sup>th</sup> edition

1. Study of various parts of a Programmable Logic Controller
2. PLC programming for sequential operations.
3. Application of Timers & Counters in PLC programming
4. Exposure to Virtual Flexible Manufacturing System.
5. Exposure to complete FMS
6. Experimentally determination of the natural frequencies, damping ratios and the viscous friction coefficient of the joint of a flexible arm mounted on a servo motor using smart sensors and software LABVIEW.
7. Experimental verification of the kinematics of rigid multi link robot manipulators.
8. Experimental implementation of PID control for the single link rigid arm manipulator using software LABVIEW.
9. Experimental implementation of PID control for the single link flexible arm manipulator using smart actuators and the software LABVIEW.
10. Experimental implementation of PID control for the multi link rigid arm manipulator using software LABVIEW

Metal Cutting and Forming Laboratory would include following experiments:

1. To study the working and different operation in case of Hydraulic Press.
2. To study and analyse the forming parameters such as forming speed on the material defects and surface finish for the deep drawing operation using hydraulic press.
3. To study and analyse the effect of variation in work piece material on surface finish for the deep drawing operation using hydraulic press.
4. To study and analyze the process parameters for variation in output for Drawing operation.
5. To study and analyse the effect of change in speed on wear of cutting tool using Dynamometer & Sensors for condition monitoring.
6. To study and analyse the effect of change in feed on wear of cutting tool using Dynamometer & Sensors for condition monitoring.
7. To study and analyse the effect of change in depth of cut on wear of cutting tool using Dynamometer & Sensors for condition monitoring.

Historical development of assembly process.

**Automatic assembly transfer system:** Continuous transfer, intermittent transfer, indexing mechanism

**Automatic feeding and orienting:** vibrators, Mechanical feeders: Analysis of feeders and orienting devices Feed tracks, escapements, part placements Mechanisms: gravity feed tracks, Power feed tracks

**Performance and economic assembly system:** Indexing machines, free transfer machines, basics for economic comparison of automatic equipment, comparison of indexing and free transfer machines.

**Design for manual assembly:** Product design for high speed automatic assembly. Printed circuit board assembly, Feasibility for assembly automation

#### **Recommended Books**

1. Assembly automation and product Design, Geoffrey Boothroyd, Taylor and Francis, CRC press, 2005
2. Boothroyd, G. and Poli, C. Automation Assembly, Marcel Dekkar, New York, 1982.
3. Groover M P , Automation, Production Systems & CIMII Pearson Education Asia, 2<sup>nd</sup> edition

**Advanced Metallic Systems:** Steels for special applications, Austempered Ductile Iron.

**Advanced Polymeric Materials:** New polymeric materials such as Kevlar. Advanced design with and fabrication of polymers. Case studies.

**Advanced Ceramic Materials:** Advanced powder synthesis techniques. Advanced processing methods. Microstructural design and grain boundary engineering. Case studies.

**Introduction to Composite Materials:** Phase selection criteria. Reinforcing mechanisms. Interfaces, advantages and disadvantages.

**Polymer Composites:** Reinforcing and matrix materials. Prepregs. Fiber winding techniques. Fabrication techniques. Laminates. Mechanical behaviour, etc.

**Metal Composites:** Types of reinforcement. Chemical compatibility. Fabrication processes. Mechanical behaviour and properties. Case studies.

**Ceramic Composites:** Matrices and reinforcement. Why to reinforce ceramics. Fabrication methods. Crack propagation and mechanical behaviour.

**Surface Engineering:** Reasons for surface engineering. Introduction to surface modification processes including: Carburizing, Nitriding, Nitrocarburizing, Ion Implantation, Shot Peening and laser techniques. Introduction to coating processes including: Plating, PVD, CVD and Thermal Spraying. Characteristics/applications/limitations of the various techniques.

### **Recommended Books**

1. King R.G., Surface treatment and finish of aluminium, (Pergamon Press)
2. Straafford K.N., Datta P.K., Grag J.S., Surface Engineering Practice, (Ellis Horltoow)
3. Richorson R.W., Modern Ceramic Engineering, (Marcel Dekker)



**Characteristics of projects**, Definition and objective of project management, Stages of project management. Role of project manager. Project Definition, Financing the projects, Cost estimating and cost control.

**Planning and Scheduling of Activity Networks**, Fulkerson's Flow Algorithm and other Heuristic Rules. Basic PERT/CPM Calculations, Assumptions in PERT Modeling, Time-cost Trade-offs, Linear Programming and Network Flow Formulations, PERT/COST Accounting, Scheduling with limited resources, Precedence Diagrams, Decision CPM, Generalized Activity Networks, GERT, Prospects of PERT/CPM, Resource Scheduling.

**Managing Progress**, Time-Cost Trade-off and generation of the Project Cost Curve in Deterministic Networks. Motivating the participants, integrated systems for planning and control. Limitations of Network Models. Case Studies and Problems.

### Recommended Books

1. Kerzner Harold, Project Management, A Systems Approach to Planning, Scheduling and Controlling, CBS Publishers, Delhi, 2002.
2. Weist Jerome D and Ferdinand K. Levy, A Management Guide to PERT/CPM with GERT/PDM/DCPM and other networks, Prentice-Hall of India: New Delhi.
3. Parsanna Chandra: Project Planning, Analysis, Selection, Implementation and Review, Tata McGraw Hill, 2002.
4. L.S. Srinath, PERT & CPM Principles and Applications, Affiliated East- West Press Pvt. Ltd., New Delhi.
5. Moder, Philips & Davis, —Project Management with CPM, PERT and Precedence DiagrammingII, CBS Publishers, Delhi.

### Part –A Theory

**Basics:** Introduction, control system representations in transfer function form, impulse response of a system, frequency response of a system, single input single output systems, multi input multi output systems, stabilities, signals and system norms, vector norms and signal norms system norms, continuous time and discrete time systems, introduction to classical control methods.

**Modeling of uncertain systems:** Parametric uncertainty, linear fractional transformations, structured uncertainties

**Robust Control Design:** Robust design specifications, small gain theorem and robust stabilization, performance consideration, two degree-of-freedom  $H^\infty$  design, sub-optimal solutions, direct formulae for  $H^\infty$  sub-optimal central controller

### Part ---B Applications

**Control of a mass-damper-spring system:** System model, frequency analysis of uncertain system, design requirements of closed-loop system, system interconnections, sub-optimal  $H^\infty$  controller design, analysis of closed-loop system with  $H^\infty$  controller

**Control of a triple inverted pendulum :** System description, modeling of uncertainties, design specifications, system interconnections,  $H^\infty$  design, nonlinear system simulation

**Control of a hard disk drive:** Hard disk drive servo system, derivation of uncertainty model, closed-loop system design specifications, system interconnections, controller design in continuous-time design,  $H^\infty$  design nonlinear system simulation

**Control of a flexible-link manipulator:** Dynamic model of the flexible manipulator, a linear model of the uncertain system, system performance specifications, system interconnections, controller design and analysis, nonlinear system simulations,

**Control of Rolling Mill:** Dynamic model of the rolling mill, a linear model of the uncertain system, system performance specifications, system interconnections, controller design and analysis, nonlinear system simulations,

### Recommended Books

1. Robust Control Design with MATLAB by DW Gu, Springer, New York
2. MATLAB Tool Box for LTI Control by Math works
3. MATLAB Tool Box for SIMULINK by Math Works
4. Advanced theory of vibrations II By JS Rao, Wiley Eastern New Delhi
5. Introduction to Robotics, JJ Craige, Pearson education, New

**Managing the digital firm:** Concepts, need and scope of Information system in business organization, the competitive business environment and the emerging digital firm, transformation of business enterprise, major business functions, approaches to the development of an organization's information system; technical approach, behavioral approach, socio – technical approach, new options for organization design, the Network revolution, Internet and its functions, World Wide Web, LAN etc., positive & negative impacts of information systems.

**Information systems in the enterprise:** Organizational levels, subsystems of information system; operational level, knowledge level, management level and strategic level information systems, transaction processing systems, office automation systems, knowledge work systems, MIS, DSS, ESS, relationship of various information systems to one another, systems from a functional perspective, System development life cycle, Nolans model of growth of MIS in an organization, introduction to ERP

**Managing data resources:** Components of computer based information system (CBIS), file organization terms & concepts, problems with traditional file environment, Database Management System (DBMS), types of Databases, Relational DBMS, hierarchical & network DBMS, Object oriented databases. Data mining.

**Decision making :** Steps in decision making, Simons model of decision making, Types of decisions i.e. structured and unstructured decisions, Departmental , inter departmental and organizational decisions, role of MIS in decision making

**Logical database design:** Entity relationship diagram, properties of tables, update anomaly, insertion anomaly, deletion anomaly, inconsistency anomaly, repeating groups, primary key and concatenated key, Normalization, 1NF to 2NF to 3 NF steps.

**Artificial intelligence:** Expert system, features of an expert system, heuristic and algorithm, human expertise vs. artificial expertise, knowledge representation: rule-based methods & frame-based methods, tasks and stages of expert system development and difficulties in developing an expert system.

**Computer simulation:** concept of simulation, when is simulation an appropriate tool, when simulation is not appropriate, advantages and disadvantages of simulation, areas of application, systems & system environment, components of a system, discrete & continuous systems, model of a system, types of models, steps in a simulation study, simulation application examples, selecting simulation software.

**Introduction to SQL :-** Practice of basic commands of SQL, development of MIS for simple business situations

### **Recommended Books**

1. Laudon Kenneth C and Laudon Jane P, *Management Information Systems*, Pearson Education Asia, Eighth Edition (2004)
2. Donald A Waterman, *A Guide to Expert Systems*, Pearson Education Asia, Third Indian Reprint (2002)
3. Banks Jerry...[et al.], *Discrete Event System Simulation*, Pearson Education Asia, Third Edition (2001)
4. Davis & Olson, *Management Information Systems*, McGraw Hill International Editions.
5. Parker & Case, *Management Information Systems*, McGraw Hill International Editions.

**Introduction:** The concept, classification of non-conventional machining processes, the benefits and limitations over conventional machining processes

**Mechanical Processes:** Ultrasonic machining (USM): Process, elements of process, cutting tool system design, mechanics of cutting, effect of various parameters on MRR, applications of USM, limitations, recent developments.

**Abrasive jet machining(AJM):** Process, applications, advantages and disadvantages, variables in AJM like carrier gas, types of abrasives, grain size, jet velocity, work material, nozzle design etc., MRR in AJM, nozzle wear, jet cutting equipment, process details, practical applications.

**Electrochemical machining (ECM):**Process introduction, elements of ECM process, electrolytes and their properties, EDM machine set up, chemistry of the process, calculation of MRR, tool design, work material characteristics, advantages and limitations, applications, process faults.

**Electrochemical grinding and electrochemical deburring:** Introduction, special characteristics as compared to other processes, advantages and limitations, applications.

**Chemical machining:** Process introduction, elements of process, advantages and limitations, applications.

**Thermal metal removal processes:** Detailed study of electrodischarge machining (EDM), plasma arc machining (PAM), electron beam machining (EBM), laser beam machining (LBM), hot machining - Process introduction, mechanism of metal removal, set up and control of parameters, recent developments.

#### **Recommended Books**

1. Pandey and Shan, Modern Machining Processes, Tata McGraw hill Publishing Compant Limited New Delhi (2004)
2. Serope Kalpakjian, Manufacturing Process for Engineering Materials, Addison - Wesley Publishing Company, 1997.

**Introduction to LCA**

Mechanization and automation, Rigid and flexible automation, Degree of automation, Manufacturing cycles, productivity, favorable conditions for the automation.

**Technologies for LCA**

Mechanical, Pneumatics, Hydraulics, Electrical, Hybrid, etc. Comparative merits and limitations.

**Pneumatics**

System synthesis, developing mechanical systems, elements, synthesis, Illustrative examples Pneumatics, types of actuators, pressure, flow and direction, control valves, auxiliaries, symbols, synthesis of circuit

**Hydraulics**

Hydraulics, pumps and power packs, actuators, valves, accumulators and intensifiers, oil and filtration, symbols, synthesis of simple circuits, hydraulic servo mechanism, Illustrative examples for various industrial applications

**Introduction to Mechatronics Sensors and Actuators**

Intelligent Control for LCHA, Hardware Components, Stepper motor, interfacing with Actuators, Signal Conditioners, Control Strategies, Popular Controllers. New trends in material handling - Storage & retrieval/ AGVs/ Intelligent conveyors. Pick & place units. System integration. Modular Flexible Assembly Lines – advantages, areas of applications, examples

**Recommended Books**

1. Pneumatics and Hydraulic system, W Bolton, Butterworth-Heinemann, June 1997
2. Fluid Power with Application, Anthony Esposito, Pearson Education, 2000
3. Pneumatic Systems, SR Majumdar, Tata McGraw, Sept, 1995
4. Pneumatics and Hydraulics: A Revision of Fluid Power, by Harry L. Stewart, T. Audel, 1976
5. Gavrillov, A.N., Automation and Mechanization of Production Processes in Instrument Industry, Pergamon Press, Oxford, 1967.
6. Pippenger, G., Industrial Hydraulics, MGH, New York, 1979.
7. Kay, F., Pneumatics for industry, The Machining Publ. Co., London, 1959.
8. Boothroyd, G. and Poli, C. Automation Assembly, Marcel Dekker, New York, 1982.

**Supply chain drivers and obstacles:** Four drivers of supply chain – inventory, transportation, facilities, and information, a framework for structuring drivers, role of each driver in supply chain, obstacles to achieve strategic fit.

**Supply chain performance:** Objectives of supply chain, stages of supply chain, supply chain process cycles, customer order cycle, replenishment cycle, manufacturing cycle, procurement cycle, push/pull view of supply chain processes, importance of supply chain flows, examples of supply chain, supply chain strategies, achieving strategic fit, product life cycle, the minimize local cost view, the minimize functional cost view, the maximize company profit view, the maximize supply chain surplus view.

**Managing economies of scale in a supply chain:** Role of cycle inventory in a supply chain, economies of scale to exploit fixed costs, economies of scale to exploit quantity discounts, short term discounting, estimating cycle inventory related costs, determining appropriate level of safety inventory.

**Transportation in a supply chain:** Facilities affecting transportation decisions, modes of transportation and their performance characteristics, design options for a transport network, trade-offs in transportation decision, tailored transportation, routing and scheduling in transportation, making transportation decisions in practice.

**Logistics and Competitive Strategy:** Competitive advantage, gaining competitive advantage, advantage through logistics, mission of logistics management, supply chain and competitive performance, changing logistics environment.

**Measuring logistics costs and performance:** The concept of total cost analysis, principles of logistics costing, logistics and the bottom line, logistics and shareholder value, customer profitability analysis, cost drivers and activity based costing.

**Benchmarking the supply chain:** Benchmarking the logistics process, mapping supply chain processes, supplier and distributor benchmarking, identifying logistics performance indicators, setting benchmarking priorities.

**Coordination in a supply chain:** Lack of supply chain coordination and the Bullwhip effect, effect of lack of coordination on performance, obstacles to coordination, managerial levers to achieve coordination, achieving coordination in practice.

### Recommended Books

1. Martin Christopher, Logistics and Supply Chain Management, Pearson Education Asia (2002).
2. Peter Meindl , Supply Chain Management – Strategy, planning and operation's, Pearson Education ,Asia (2002).
3. Kapoor K K, Kansal Purva, Marketing logistics: A Supply Chain Approach, Pearson Education Asia (2002).
4. Buffa, Modern production/operations Management, Wiley Eastern Ltd. (2000)
5. Alan Muhlemann, John Oakland and Keith Lockyer, Production and operation Management, Macmillan India Publications (2000)
6. K.Aswathappa,K.S.Bhat, Production and Operations Management, Himalaya Publishing House, Mumbai (2000).
7. R.Panneerselvan, Production and operations Management, Prentice Hall of India, Delhi (2000).

Introduction to metal cutting, machine tools - Criteria for the selection of operating capacity and design parameters, kinematics of machine tools, basic principles of machine tool design, estimation of drive power, machine tool drives - electrical, mechanical and fluid drives, stepped and step-less speed arrangements and systems.

Design of machine tool spindles and bearings. Design of power screws, slide ways, selective and pre-selective mechanisms.

Machine Tool Structures - Beds, Columns, Tables and Supports, Stock feed mechanism, Measurement and Control of machine tools, Protective and Safety devices.

Design of precision machine tools, Micro-feeding mechanisms, Concepts of modular design and integration for SPMs.

Concepts of Aesthetics and Ergonomics applied to machine tools, Acceptance tests and Standardization of machine tools, Machine tool reconditioning. Latest trends in machine tool design, Introduction to CAD techniques.

Design/selection of linear motion systems, ball, screws, CNC feedback devices, controllers, feed drives, and servo motors for CNC machine tools.

#### **Recommended Books**

1. Mehta N.K., Machine Tool Design, Tata McGraw Hill, New Delhi.
2. Acherkan N., Machine Tool Design, Vol 3&4, Mir publisher, Moscow.
3. Koenigsburger A., Design Principles of Metal Cutting & Machine Tools, Pergamon Press.
2. C.M.T.I. Machine Tool Design Course Notes, C.M.T.I., Bangalore.
3. Sen G. and Bhattacharya A., Principles of Machine Tools, Vol 2. NCB, Calcutta.

**Statistical process control:** causes of variation, chance and assignable causes, statistical basis for control charts, basic control charting principles, selection of control limits, errors in making inferences from control charts, Type-1 errors, Type II errors, effect of control limits on errors, effect in inference making, effect of sample size on control limits, sample size, frequency of sampling. Theory of Runs, interpretation of plots, determination of causes of out of control points, maintenance of control charts. Control charts for mean and range, control charts for mean and standard deviation, control charts with variable subgroup size, control charts with reject limits.

**Control charts for attributes:** advantages and disadvantages of attributes charts, preliminary decisions, charts for proportion non-confirming (p-chart), construction and interpretation, variable sample size, observations below the lower control limit, information about the overall quality level. Charts for non-confirming items (np chart), chart for number of non-conformities (c chart), and classification of non-conformities.

**Process capability analysis:** Introduction, specification limits and control limits, process capability, process capability analysis, benefits of process capability analysis, process capability indices, the  $C_p$  index, upper and lower capability indices, the  $C_{pk}$  index, capability ratio, gage repeatability and reproducibility, process capability analysis procedure using individual observations and control chart information.

**Acceptance inspection:** sampling inspection, 100% inspection, no inspection, acceptance sampling plans for attributes and variables, advantages and disadvantages of sampling, producer's risk and consumer's risk, operating characteristic curve, effect of the sample size and acceptance number on the operating characteristic curve. Types of sampling plans: single double, multiple and sequential sampling plans, relative advantages and disadvantages.

**Evaluating sampling plans:** average outgoing quality, average outgoing quality limit, average total inspection, average sample number, AQQ Curve, ATI curve, ASN curve. Design of sampling plans. Economics of Acceptance Inspection. Standard sampling plans: Dodge Roming plans and MIL-STD 105 E.

**Quality assurance:** definition, characteristics of quality assurance system. ISO-9000: scope, application, terms and definitions, evolution of ISO-9000 series, process approach, PDCA methodology, documentation requirement, guidelines for preparation of quality manual. Steps for certification, implementation schedule for certification, benefits of ISO -9000 implementation.

**Quality audit:** definition, internal audit, second party, third party audit, pre-assessment and compliance audit, procedure of auditing, audit planning, audit execution. Case study on ISO-9000 implementation.

### Recommended Books

1. Grant E L and Leavenworth R S, Statistical Quality Control, McGraw Hill. (2000)
2. Hansen Bertrand L and Ghare Prabhakar M, Quality Control and Applications, Prentice Hall of India Pvt. Ltd. (1993)
3. Amitav Mitra, Fundamentals of Quality Control and Improvement, Pearson Education Asia, First Edition (2001)
4. Besterfield Dale H [et...al.], Total Quality Management, Pearson Education Asia, First Edition (2001)
5. A. Zaidi, SPC: Concepts, Methodologies and Tools, Prentice Hall of India, (1995)



**Environment Management:** Planning and Management of Environmental Impact Studies. Impact indentation methodologies: base line studies, screening, scoping, checklist, networks, overlays. Prediction and assessment of impacts on the socioeconomic environment. Environmental cost benefit analysis. Preventive environmental management.

**Environment Assessment:** Environmental property and processes, Environmental simulation models, Elements of environmental impact analysis, Impact assessment methodologies, Framework of environmental assessment, Environmental impact of water resources projects, Assessment of hydrological hazards, Case studies.

**Engineering products and processes:** Environmental health and safety, Product life cycle stages, Material toxicity, pollution, and degradation, environmentally conscious design and manufacturing approaches, Sustainable development and industrial ecology. System life-cycles from cradle to reincarnation, Product life-extension, Organizational issues. Pollution prevention practices, Manufacturing process selection and trade-offs.

**Waste water from Industries:** Pollution-harmful effects, waste water characteristics, mixing of industrial and domestic waste, Pre-treatment of industrial waste-reduction of waste, strength and volume equalization & neutralization. Water born disease, hardness of water, chlorination of water, fluoridation of water.

**Air pollution:** composition, air of occupied rooms, discomfort, indices of thermal comfort, comfort zones, air pollution sources, pollutant, indications of air pollution, health and other aspects of air pollution, prevention and control disinfection of air.  
Noise pollution: Definition, effect of noise, exposure, noise control.

**Design for Environment:** Motivation, concerns, definitions, examples, guidelines, methods, and tools. Recyclables assessments, Design for recycling practices. Remanufacturability assessments, Design for Remanufacture / Reuse practices. Industrial ecology and Eco-industrial parks. Eco-Labels and Life-Cycle analysis (LCA): LCA methodology, steps, tools and problems, Life-Cycle Accounting and Costing. ISO 14000 Environmental Management Standards. New business paradigms and associated design practices.

**Pollution Control Board:** Legal aspects, court judgments, functions of pollution control board, Environmental audit, audit items, audit procedure, safety audits.

### Recommended Books

1. R RajaGopalan, Environmental Studies, Oxford University Press, New Delhi.
2. Metcalf & Eddy, Waste water Engineering, Pearson Education.
3. M N Rao, Air pollution, Tata McGraw Hill New Delhi.
4. Larry W Canter, Environment Impact Assessment, Tata McGraw Hill New Delhi.
5. Linsey R K, Water resources and Environmental Engineering, Tata McGraw Hill New Delhi.
6. S P Mahajan, Pollution control in Process Industries, Tata McGraw Hill New Delhi.
7. Garg S K, Environmental Engineering, Khanna Publishers New Delhi 2003

**1. Basic concepts:** Variational and Residual methods-Introduction - Different approaches in Finite Element Method - Direct Stiffness approach, simple examples Variational approach, Elements of variational calculus – Euler's-Lagrange equation, Rayleigh Ritz method , Weighted Residual methods, Point Collation method, Sub domain Collation method, Galerkins method - Steps involved in FEM.

**2.Elements and Interpolation Functions:** Elements and coordinate system -Interpolation Polynomials - Linear elements Shape function - Analysis of simply supported beam - Element and Global matrices - Two dimensional elements, triangular and rectangular elements - Local and Natural Co-ordinate systems.

**3. Finite Element Solution of Field Problems:** Field problems – Finite element formation of field problems - Classification of partial differential equations - Quasiharmonic equation - Steady state problems - Eigen value problems - Propagation problems - Examples, Torsional problem - Fluid flow and Heat transfer problems - Acoustic vibrations – Application in manufacturing problems – metal cutting and metal forming.

**4. Finite Element Solution of Structural Problems:** Solid mechanic problems – Finite element formulation of solid mechanic problems - Axial force member - element matrices for axial force members - Truss element analysis of pinned truss - Two dimensional elasticity problems.

**5. Higher Order Elements and Numerical Methods:** Numerical method and computer implementation –Numerical method in FEM and Computer implementation. Evaluation of shape functions - One dimensional & triangular elements, Quadrilateral elements, Isoparametric elements - Numerical Integration, Gauss Legendre quadrature - Solution of finite element equations - Cholesky decomposition, Skyline storage - Computer implementation- Use of FEM software.

### Recommended Books

1. Larry J Segerlind ,— Applied Finite Element AnalysisII, John Wiley, 1984
2. Bathe, K.J., —Finite Element ProceduresII, Prentice Hall, 1994.
3. Huebner,K.H. and Thornton, E.A., —The Finite Element Method for EngineersII, John Wiley, 1982.
4. Reddy,J.N., —Introduction to Finite Element MethodII, McGraw Hill, 1993
5. Zienkiewich . O.C., and Taylor . R.L., —The Finite Element MethodII, McGraw Hill,1991.
6. S.S.Rao, —Finite element method —, 1995.

**Introduction:** Statistics and Engineering, Pareto diagram and dot diagram, frequency distributions, graphical representation of data, quartiles and other percentiles, calculation of mean and standard deviation

**Probability:** Sample space and events, definition of probability, the axioms of probability, some elementary theorems like addition and multiplication theorem, conditional probability, bayes theorem, mathematical expectation and decision making, random variable, Binomial, hypergeometric, Poisson and normal distributions

**Sampling distribution and inferences:** Population and samples, sampling distribution of mean ( $\sigma$  known and unknown), sampling distribution of variance, point estimation and interval estimation, null hypothesis and testing of hypotheses, hypotheses concerning one mean and two means, hypotheses concerning one variance and two variances, hypotheses concerning one and two proportions, goodness of fit test

**Non Parametric Tests:** The sign test, rank sum tests, test of randomness, the Kolmogorov-Smirnov and Anderson-Darling tests

**Curve Fitting:** Method of least square, correlation, single and multiple regressions

**Analysis of Variance:** Some general principles, completely randomized design, randomized block design, multiple comparisons, two factors and multiple factors experimentation

#### **Recommended Books**

1. Johnson A. Richard , Miller 7 Freund's Probability & Statistics for engineers, Pearson Education Asia, 6<sup>th</sup> edition
2. Singh Sukhminder, Bansal M.L., Statistical methods for research workers, Kalyani publishers , 2<sup>nd</sup> edition reprinted 2001
3. Richerd a Johnson, Dean w Wickern, Applied multivariate statistical analysis, Pearson Education Asia, 5<sup>th</sup> edition

The simplex algorithm, post optimality analysis, duality in l.p., dual simplex method, revised simplex method.

Transportation algorithm and optimality, assignment model, Hungarian method. decision making under certainty, risk and uncertainty, game theory, two-person zero-sum game, mixed strategy.

Elements of queuing model, single channel infinite population model, finite queue length, pure birth and death model, multi channel queuing model.

Goal programming, problem formulation, the weighting method, primitive method.

Integer programming, problem formulation, branch-and-bound algorithm, zero-one implicit enumeration algorithm.

Non-linear programming, direct search method, gradient method. Separable programming, quadratic programming.

Simulation, basic concepts, generation of random numbers and events using Monte Carlo method, mechanics of discrete simulation.

### **Recommended Books**

1. Taha, H.A., Operations Research - An Introduction, Sixth Edition, Prentice Hall of India Private Limited, N. Delhi, 1997.
2. Hillier, F.S., Operations Research, First Indian Edition, CBS Publishers and Distributors, Delhi, 1994.
3. Wagner H.M., Principles of Operations Research, Second Edition, Prentice Hall of India Private Limited, New Delhi, 1996.
4. Mustafi C.K., Operations Research, Third Edition, New Age International Pvt. Ltd., New Delhi, 1996.
5. Gupta P.K., and Hira, D.S., Operations Research, Third Edition, S. Chand and Company Ltd., New Delhi, 1997.

**Introduction to data bases:** Artificial Intelligence, Need for Knowledge based systems in Mechanical Engineering. Representation of knowledge: Conceptual dependencies, Semantic Networks, Frames, Production Systems. Object oriented Data bases for Knowledge Based Systems.

**Control structures:** Exhaustive search, Pruning, Search methods. Methods of Inference. Top down and bottom up approaches. Control structures with uncertainty. Certainty factors.

**Fuzzy theory:** Machine learning. Knowledge Engineering : Languages and Tools for Knowledge Engineering. Completeness and consistency in Rule-based systems. Expert system development. Expert system support environment.

**Neural Networks:** Fundamentals of Parallel Processing. Hopfield Network. Artificial Neural Networks. Application of Neural Networks: Inspection, Vision, Real-time Process Control, Diagnostics of machines and multisensor integration, approaches to die and tool design. Design compatibility analysis for simultaneous engineering.

#### **Recommended Books**

1. Keer, R. Knowledge Based Manufacturing Management, Addison-Wesley, 1991.
2. Addis, T.T., Designing Knowledge Based System, Prentice Hall, 1985.
3. Rolston, D.W. Principles of Artificial Intelligence and Expert Systems Development, McGraw-Hill, 1988.
4. Hung, P.W.H. and Lovergrove, G., Industrial and Engineering Applications of AI and Expert Systems, Gordon and Breach Science Publ..
5. Maus, R. and Keyes, J., Handbook of Expert Systems in Manufacturing, McGraw-Hill, 1991

### Maintenance Engineering

**Introduction:** Role of maintenance in the organization, system approach, objectives of maintenance, types of maintenance systems, Principles of maintenance

**Planned Preventive Maintenance:** Elements of PPM, work planning and scheduling, workload estimation, manpower estimation, work order procedure, planned maintenance procedure, development of checklists

**Maintenance planning:** Long range planning, short range planning, planning techniques, planning procedure, estimation of maintenance work

**Maintenance evaluation:** Need of evaluation, types of evaluation, statistical analysis of performance, selection of work measurement methods, cost of maintenance evaluation, life cycle costing

**Development of maintenance engineering practices:** Tribology practices, terro-technology practices, indigenous substitution, reconditioning, advanced strategies

**Maintainability:** Concept, maintainability measures, FMEA analysis, FTA analysis, availability, system downtime

### Reliability Engineering

**Introduction:** Concept, certain and impossible events, complementary events, Kolmogorov Axioms, definition of reliability

**Failure data analysis:** Failure data, mean failure rate, MTTF, MTBF, calculation from filed data

**Hazard models:** Introduction, constant hazard, linearly increasing hazard, The Weibull Model, distributions functions and reliability analysis

**System Reliability:** Conditional probability, multiplication rule, Venn diagram, Bayes' theorem, calculation of system reliability for series, parallel and mixed configuration, logic diagram, Morkov models and graphs

**Reliability improvement:** Element and unit Redundancy, standby redundancy, fault tree construction, tie set and cut set methods

### Recommended Books

1. Clifton R H, Principles of Planned Maintenance, McGraw Hill, New York, 2001.
2. Higgins, Handbook of Maintenance Management, Prentice Hall, New York, 1999.
3. Srinath L S , Reliability Engineering, Affiliated East-West Press Limited, New Delhi, 2002.
4. Dhillon B S, Engineering Maintainability, Prentice Hall of India, New Delhi, 2000.
5. Wireman Terry, Preventive Maintenance, Reston Publishing Company, Reston Virginia, 1998.

**Product design process:** Introduction, Importance of product design, Detail description of design process, Organization for design, Computer Aided Engineering, Designing to codes and standards. Considerations of good design, Product and process cycle.

**Product planning:** Idea for new business activity, Idea finding, product policy. Strict development; the technical development process and an iterative process, the commercial development process, Product development as a whole.

**Analysis:** from Design problem to Design specification; Problem definition, Types of objectives in design specification, Desirable properties of the design specifications, making a design specification, Quality function deployment.

**Simulation:** Predicting the properties of a design; Introduction, The simulation process, Simulation and prediction, Simulation models; Structure models, Iconic models, Analogue models, Mathematical models, Simulation in product design; Technical simulation, Ergonomic simulation, Business economic simulation, Social and ethical simulation, Simulation of environment effects.

**Cost Optimization of design:** Need of optimization of preliminary design by identification of design requirements and by use of appropriate design strategy. Introduction to detail design optimization by simulation, prototyping and optimum selection of configuration, materials and processes. Mechanical System Design problem economic political environment, issues of human safety & welfare, and professional ethics. Overview and application of optimization methods to machine elements and mechanical system design. Prototyping, Optimum selection of material & processes in mechanical design using material selection charts and optimization methods. Optimizing product design functionality, aesthetics and economics by employing industrial design principles and by suitable selection of material & processing including use of polymers, composites and other non metallic materials.

### Recommended Books

1. George E. Dieter, Engineering Design, Tata McGraw Hill publications.
2. NFM Rozenberg and J Eekels, Product design fundamental, Johan Willey Publications.
3. Karl T Ulrich and Eppinger Steven D, Product design and development, Tata McGraw Hill Publications.
4. Otto Kelvin and Wood Krista, Product design, Pearson Education, Delhi, 2001.
5. Bruce M and Copper Rachel, Creative product design, Johan Willey & sons Ltd., New York, 2000.

**Introduction** to Value Engg. & Value Analysis, Methodology of Value Engineering. Differences from Conventional Methods of Cost Reduction.

**Quantitative definition of Value.** Reasons for existence of unnecessary costs. Types of Value. Use Value & Prestige value, estimation of product quality or performance. Types of functions. Relationship between use functions & esteem functions in product design. Functional cost & functional worth. Effect of Value improvement on profitability, tests for poor Value. Aims & objectives of Value Engg -- Systematic Approach.

**Value Engg Job Plan** -- detailed study of various phases and techniques of the Job Plan. Factors governing selection of projects & products for Value analysis. Primary & secondary functions, work & sell functions, determining and evaluating functions, assigning equivalence, determining alternate means to perform required functions. Function-cost matrix evaluation.

**Brainstorming & Creativity.** Creative Thinking and Creative Judgment, positive or constructive discontent. Tangible & Intangible costs of implementation. False material, labour & overhead savings. V.E. Yardsticks. Relationship between savings & probability of success of a V.E. project. Reporting, Implementation & Follow Up.

**Advanced Techniques** like FAST (Function Analysis System Technique). Case Studies in Value Engineering.

### **Recommended Books**

1. Mudge Arthur E, Value Engineering - A Systematic Approach, McGraw Hill Book Co., New York.
2. Zimmerman & Hart, Value Engineering - A Practical Approach, CBS Publishers & Distributors, New Delhi.
3. R.D.Miles, Techniques of Value Analysis & Engineering, McGraw Hill Book Co., New York.
4. T.C. Fowler, Value Analysis in Design, VNR Publishers, New York.
5. M.S. Vittal, Value Engineering for Cost Reduction and Product Improvement, Syncons Publications, Bangalore.



Introduction to Materials Management. Materials productivity and role of materials management techniques in improved materials productivity. Integrated approach to Materials Management. Cost reduction and value improvement. Role of purchasing in cost reduction. Value analysis for right choice and rationalization of materials.

Purchasing research identification of right sources of supplies. Vendor rating. Standardization and variety reduction. Negotiations and Purchase Price Analysis. Organization of purchasing function. Make or buy decision. Incoming materials control acceptance, sampling inspection. Vendor certification plans. Vendor and supply reliability.

Inventory management. ABC, VED, FSN analysis. Various inventory models. Inventory models with quantity discount. Determination of safety stock; Service levels and uncertainty in demand. Exchange curve concept and coverage analysis. JIT. Information systems for inventory management. Stores management and warehousing. Optimal stocking and issuing policies. Inventory management of perishable commodities. Surplus management. Inventory distribution systems. Monitoring MM effectiveness. Case studies.

### **Recommended Books**

1. Arnold & Chapman, Introduction to Materials Management, Pearson Education Asia, 2001.
2. Narsimhan, Mcleavey & Billington, Production Planning & Inventory Control, Prentice Hall of India, 1997.
3. Donald W. Dobler, David N. Burt, Purchasing and Supply Management, Tata McGraw Hill, 2001.
4. Gopalakrishnan P., Handbook of Materials Management, Prentice Hall of India, 1997.
5. Heizer and Render, Principles of Operations Management, Pearson Education Asia, 2001.

**Introduction:** Nature of managerial and social systems, existing approaches, mental models, learning and reasoning – microworld concept, impact of policies, justification.

**Systems Dynamics Methodology:** Historical development, foundations of systems dynamics, philosophy of systems dynamics, conceptual framework, view points and features of systems dynamics, flexibility in methodology, strengths and weaknesses.

**Use of systems dynamics in managerial problems:** Characteristics of managerial problems matching systems dynamics modeling, top management problems, middle management problems, operational management problems, functional management problems, management support system.

**Systems Dynamics Model:** Definition, an example model, the manager's dilemma, nature of variables, diagramming aids, equations, feedback structures, dynamic behavior, delays and smooths, functions.

**Develop a systems dynamics model:** Identification of problem situations, to carry out situation analysis and prepare statement, selection of modeling approach, preparation of a subsystem diagram, policy structure diagram, causal loop diagram, writing equations.

**Checking of the principles:** Principles of model boundary, order of the model, coherence of feedback loops, level and rate relationships, principles of conservative subsystem, principles of information subsystems, dimensional consistency, solution interval.

**Simulate and validate a system dynamics model:** Parameters estimation, initialization of levels, software packages for simulation.

**Testing and analysis:** Understanding model behavior, sensitivity analysis, model refinement and reformulation, policy analysis with parameter changes and structural changes, scenario building.

### Recommended Books

1. Sushil (2002), System Dynamics- A practical approach for managerial problems, Wiley Eastern Limited New Delhi.
2. Checkland P (1981), Systems thinking, systems practice, John Wiley and Sons, New York.
3. Gould J M (1992), Artificial Intelligence: A tool for system dynamics, Russell Sage Foundations, NY, USA.
4. Katsuhiko Ogata (2003), System Dynamics, MIT Press, Cambridge.
5. Sterman (2000), Business Dynamics: Systems Thinking and Modeling for a Complex World, Irwin McGraw Hill Limited.

**Introduction:** Definition, nature, scope, and importance of strategy; and strategic management (Business policy). The Strategic management model, Benefits of strategic management.

**Strategy Formulation :** Vision and Mission statements, Importance, Characteristics and components of Mission statement.

**Environmental Appraisal**—Concept of environment, components of environment (Economic, legal, social, political and technological). Environmental scanning techniques-ETOP, QUEST and SWOT (TOWS).

**The external assessment,** Economic forces, Technological Forces, Competitive forces  
Competitive Analysis: Porters Five Force Model

**The Internal Assessment :** Integrating Strategy and culture, Management, Finance , productions/ Operations, Research and Development, management Information System, value Chain, Evaluation matrix.

**Strategies in Action:** objectives Types of Strategies, Integration Strategies, Intensive Strategies, Diversification Strategies, Defensive Strategies, Defensive strategies.

**Strategy Analysis and choice:** Nature, Frame Work of strategy analysis and choice, Input stage, matching stage, Decision stage.

**Strategy implementation:** Policies, Resource allocation, Managing Conflicts, managing Resistance to change, Leadership and corporate culture, Values, Ethics and Strategic control and operational Control. Organizational systems  
And techniques of strategic evaluation.

#### **Recommended Text Books**

1. Kazmi (2003), —Business Policy & Strategic ManagementII, Tata McGraw Hill
2. Thomson & Strickland (2004), —Strategic Management: Concept & CasesII, Tata McGraw Hill
3. Ghemawat (2005), —Strategy & The Business Landscapell, Pearson Education Asia
4. Ghoshal, Piramal (2003), —World Class in IndiaII, Penguin Publishers
5. Wheelen & Hungee (2002), —Strategic Management & Business Policy', Addison-Wesley
6. Pearce & Robinson (2003), —Strategic ManagementII, AITBS New York

Optimality criteria - Single variable optimization Algorithms: Golden section search method, Gradient based methods.

Multi variable optimization algorithms: Direct search methods, Gradient based methods, Conjugate gradient method.

Constrained optimization methods - Kuhn-Tucker Optimality Criteria - Direct search methods: Variable elimination method, complex search method, Random search method - programming exercises.

Evolutionary Algorithms: Difficulties with classical optimization algorithms, Binary Genetic Algorithms, Non Recombinative and Recombinative Evolution Strategies, Self Adaptive Evolution Strategies, Evolutionary Programming, Genetic Programming.

Multimodal Function Optimization, Multiple Pareto Optimal Solutions, Vector evaluated Genetic Algorithm, Weight-Based GA, Non Dominated Sorting GA.

Mathematical programming models and computational techniques, simplex method, post optimality analysis, duality in l.p., dual simplex method, revised simplex method, goal programming approach.

#### **Recommended Books**

1. Taha, H.A., —Operations Research - An Introduction, Sixth Edition, Prentice Hall of India Private Limited, N. Delhi, 1997.
2. Hillier, F.S., —Operations Research, First Indian Edition, CBS Publishers and Distributors, Delhi, 1994.
3. Kalyanmoy Deb, —Optimization for Engineering Design, PHI, 2000.
4. Engineering optimization, theory and practice, Singiresu. S. Rao, New Age International publishers, 1996.
5. C Reeves, —Modern Heuristic Techniques for Combinatorial Problems, McGraw-Hill, 1995

**Introduction :** Research and scholarship; difference between undergraduate and research education; skills, habits and attitudes for research; status of research in India; course objectives; course organization and time table; evaluation procedure

**Thinking Processes, problem solving and creativity:** Level and styles of thinking; common-sense and scientific thinking; examples

Problem solving strategies – reformulation or rephrasing, techniques of representation, logical thinking, division into sub- problems, verbalization, awareness of scale; importance of graphical representation; examples;

Creativity – some definitions, illustrations from day to day life; gift or skill; creative process; requirements for creativity – role of motivation and open vs closed minds; multiple approaches to a problem, analytical vs analogical reasoning, puzzle solving; examples; prepare mind, Creative problem solving using Triz, Prescriptions for developing creativity and problem solving

**Experimental and modeling skills:** Scientific method; role of hypothesis in experiment; units and dimensions; dependent and independent variables; control in experiment; precision and accuracy; need for precision; definition, detection, estimation and reduction of random errors; statistical treatment of data; definition, detection and elimination of systematic errors; design of experiments; taguchi method; experimental logic; documentation; Types of models; stages in modeling ;curve fitting; the art of making approximations; problem representation; logical reasoning; mathematical skills; finite element and Monte Carlo techniques of numerical simulation;

**Problem finding and literature survey:** Information gathering – reading, searching and documentation; types, attributes and sources of research problems; problem formulation

**Publishing and patenting:** Difference between publishing and patenting; relative importance of various forms of publication; choice of journal and reviewing process; stages in the realization of a paper or a patent and how to handle these.

**Effective communication – oral and written :** Examples illustrating the importance of effective communication; stages and dimensions of a communication process

Oral communication – verbal and non-verbal, casual, formal and informal communication; interactive communication; listening; form, content and delivery;  
Various contexts for speaking – conference, seminars, etc.; visual aids

Written communication – form, content and language; layout, typography and illustrations; contexts for writing – paper, thesis, reports, etc  
Prescriptions for developing communication skills

**Stress management, Time management, Interpersonal skills, professional ethics:**

Psychological phases of a PhD process; stress points; aims of supervisors; mismatches and problems

Managing self; empathy; managing relations with your supervisor, colleagues, and supporting staff; listening; assertiveness; teamwork; sense of humor

Duration and stages of a Ph D process; long term and short term goals; time tabling and deadlines;

Profession; integrity, objectivity, fairness and consistency; loyalty; plagiarism and research ethics; safety

### **Recommended Books**

1. E.M. Phillips and D S Pugh, —How to get a PhD – a handbook for PhD student s and their supervisorsll, Viva books Pvt. Ltd for all scholars irrespective of their disciplines.
2. Handbook of Science Communication, compiled by Antony Wilson, Jane Gregory, Steve Miller, Shirley Earl, Overseas Press Indian PVt.Ltd, New Delhi, first edition 2005.
3. G L Squires, —Practical physicsll, Cambridge University Press for all scholars except those from Humanities and Management sciences.
4. Peter B Medeq, — Advie to a Young Scientistll, Pan Books, London 1979

**Introduction:**

Concept of change, its need in the industry, indicators of organizational change, concept of competitiveness, its relationship with change, impact of change on competitiveness of an organization.

**Perspectives on change:**

The notion of environment, contingency perspective: specialization, integration, resource dependence perspective, internal and external strategies to reduce dependence, institutional perspective, results of these perspectives.

**Types of change:**

Continuous and discontinuous changes, re-invention, re-orientation and re-creation, participative and directive changes, incremental change, radical change, dynamic change.

**Change Programme:**

Parameters of change programme, forces of change, changes representing an opportunity, change representing a threat, weak forces of change, change campaigning.

**Change Process:**

Concept of change agents, drivers of change, steps to successful change: assemble a change team, establishing a vision and new direction for the organization, preparation for change, setup of change teams to implement change, align structure, systems, and resources to support change, identify and remove roadblocks, absorb changes in the organizational culture.

**Specific change programmes:**

Introduction to business process Re-engineering, lean production and lean thinking, total quality management, choosing an appropriate change programme.

**Change levers:**

Introduction to various change levers: leadership, strategy, structure, human resource management practices, technology, marketing, quality and costs, identifying various issues of organizational change in Indian context.

**Change as Organization Transformation:**

Inducing transformational change, Organizational audit as a catalyst for change, Transforming mature **organizations, Change acceleration process**

**Change tools:**

SWOT analysis, SAP-LAP analysis, tinkering and kludging, Matrix of change, Delphi study, Case studies.

**Recommended Books**

1. Nilakant V, and S. Ramnarayan, —Managing Organizational Change, Response Books, A division of sage Publications, London, 2000.
2. Johnson A Edosomwan, —Organizational Transformation and Process Reengineering, Kogan Page Limited, London, 2000.
3. Sushil, —Flexibility in Management, Vikas Publishing House, New Delhi, 2001.
4. Bernard Burnes, —Managing Change, Pitman Publishing Company, London, 1999.
5. John Storey, —Human Resource and Change Management, Blackwell Publishers, UK, 1999.
6. Stephen P Robbins, —Organizational Behaviour, Pearson Education, New Delhi, 2002.

**Machining:** Introduction, need of manufacturing and its definition Machining purpose, principle, definition and requirements, benefits of learning 'theory of Machining'

**Geometry of Cutting Tool:** Introduction, Geometry of Single point cutting tools and multiple cutting tools, Conversation of tool angles

**Machanism of Machining:** Machanism of Chip formation in Machining, Geometry, and Characteristics of continues chip formation, Chip formation in drilling, Chip formation machanism in milling

**Mechanics of Mechanism:** Generation of cutting force and effects of the cutting force in machining, Cutting force analysis and Estimation, Analysis and Estimation for force under oblique cutting, Measurement of cutting force, Design considerations for tool force Dynamometers and Their Functioning

**Heat Generation and Cutting Temperature in Machining:** Location and Causes of heat Generation in machining, Determination of cutting Temperature, Control of Cutting Temperature and Application of Cutting Fluid

**Failure life and Materials of Cutting Tools:** Major causes and Modes of failure of cutting tools, wear in cutting tools, Tool life, Cutting tool Materials.

**Estimation of Machining Time:** Significance of Machining time and Purposes of its Evaluation, Methods of Estimation of Machining time

**Machinability, Some Critical Problems and Remedial Measures:** Machinability: definition, role and ways of improving problem in critical materials and remedial approaches, Control of Chips and Chip breaking, Special technique to improve the machinability, Surface Quality of Machined components

**Grinding: Fast Machining and Finishing by Bonded Abrasives:** Introduction, Basic principles, methods, applications and requirement of grinding, grinding wheels Mechanism and Machines of Grinding, Grindability and its Improvement, Advance technology of grinding, Some Special technique to improve the grinding performance, Surface finishing technique

**Economy and Eco-Friendliness in Machining:** Introduction, Economy and optimization of Machining, optimization of process schedule and machining parameters for machining economy, Environmental problems in machining and grinding and remedial Measurement.

#### Recommended Books

1. Arshimov and Alekree, Metal Cutting Theory and Cutting Tool Design, MIR Publications.
2. Chattopadhyay A. B., Machining and Machine Tools Wiley India. 2011.
3. Peter L.B. Oxley, Mechanics of Machining, Woodhead Publishing; Second Edition, 2009)
4. Serope Kalpakjian, and Steven R Schmid manufacturing engineering and technology, Pearson publication 4<sup>th</sup> Edition 2002.
5. J. T. Black and Ronald A. Kohser, DeGarmo's Materials and Processes in Manufacturing, Wiley 11th Edition, 2011
6. Milton C. Shaw Metal Cutting Principles, Oxford Series on Advanced Manufacturing 1984



**Marketing in the twenty first century:-** Marketing Tasks, Company orientation towards market place, Changes in the business and marketing methods in 21st century.

**Strategic planning, implementation and control:-** Corporate and division strategic planning, Business strategic planning, marketing process, managing the marketing process.

**Consumer Behavior & Market Research:-** Factors affecting consumer behavior, stages in purchasing, market research, market segmentation and target market selection.

**Organizational Buying:-** Salient features, factors affecting organizational purchase marketing mix, product, product levels, product hierarchy, product line, types of distributions, Channel management decisions, product mix, product life cycle, procedure for new product development, branding and packaging.

**Developing, Differentiating and Product Positioning:-** Challenges in new product development, developing new products from ideas to strategies, Consumer adoption process, marketing through product life cycle, brand decisions, packaging and labeling

**Price:-** Pricing objectives, price elasticity of demand, methods of pricing, discounts, discriminatory pricing.

**Distribution:-** Need for middleman and their functions, vertical marketing system.

**Managing retailing, wholesaling and marketing logistics:-** Types of retailers, retailers marketing decisions, trends in retailing, Growth and types of wholesaling, wholesaling marketing decisions, trends in wholesaling, market logistics objectives and decisions.

**Promotion Mix:-** Advertising, media selection, frequency and timing of advertisement, steps in developing effective communication, sales promotion, personal selling, publicity.

**Sales Force Management:-** Recruitment, training, motivating sales representatives, controlling and evaluating.

**Services Marketing:-** Definition, Difference between goods and services marketing, promotion mix for services, growth of service sector, impact of technology.

#### Books Recommended

1. Winer Russel S , —Marketing ManagementI, Prentice Hall of India, 1998.
2. Guilitinan Joseph P , Gordon W Paul and Thomas J Madaen, —Marketing Management: Strategies and ProgramsII, Mc Graw Hill Publication, 1996.
3. Dolan Robert J, —Marketing Management: Text & CasesII, McGraw Hill Publication, 2000.
4. Lamb Charles W and McDaniel Carl D., —MarketingII, South Western College Publication, 2004.
5. Kotler Philip, —Marketing management Analysis, Planning & ControlII, Pearson Education Asia,2002.
6. Zeithmal & Bitner — Services Marketing — Tata Mcgraw Hill Publishing Company Limited New Delhi, Third Edition

**Nature and Scope of Financial Accounting:** Meaning and Development of Accounting, Functions of Financial Accounting, Accounting Principles, Concepts and Conventions, Limitations of Financial Accounting, Making Financial Accounts useful to Management.

**Financial Statements:** Accounting cycle: Journal, Ledger, Cash book, Trial balance, Trading and Profit and Loss A/c and Balance Sheet, Use and importance of Financial Statements, Limitations of Financial statements.

**Ratio Analysis:** Meaning and nature of Ratio Analysis, Use and significance of Ratio Analysis, Limitations of Ratio Analysis, Classification of ratio, Test for short-term financial position: Current liquid and Absolute liquid ratios, Efficiency and Activity ratios: Stock turnover, Debtor turnover Ratio, Average collection period, creditors turnover ratio, Average Payment Period, Test of solvency: Debt-Equity ratio, Equity ratio, Solvency ratio, and Net Worth ratio, Profitability ratios: Gross profit, Operating Expenses, Net profit and operating profit ratios, Return on Investment and Earnings Per Share.

**Statements of changes in Financial Position:** Fund flow statement, Cash flow statement.

**Corporate Finance:** Meaning, Evolution and importance of corporate finance, Approaches of finance function, contents of finance function, Relationship of finance with other business functions, financial divisions, and functions of Finance Manager.

**Sources of Finance:** Classification of sources of finance, Security financing, Ownership securities, Equity Shares, Preference Shares, Deferred Shares, Debentures and Retained Earnings, Depreciation as source of funds, factoring, commercial banks, public deposits, lease financing and mutual funds.

**Working Capital Management:** Meaning, concept and classification of working capital, Needs and objectives of working capital, Disadvantages of inadequate and redundant working capital, Principles of working capital management, Estimation of working capital requirements, Financing of working capital.

**Control of Capital Issues:** Securities and Exchange Board of India (SEBI), SEBI Act 1992, Purpose of SEBI Act, Powers and functions of SEBI, Guidelines issued by SEBI(inclusive of recent modifications), Evaluation of SEBI, Limitations of SEBI.

**Capital Budgeting:** Introduction to investment, types of investment decisions, Factors affecting investment decisions, Traditional techniques of capital budgeting: Payback Period and Average Rate of return methods, Modern techniques of capital budgeting: Net Present Value and Internal Rate of Return methods Capital Rationing.

**Recommended Books:**

1. Pandey, I M "Financial Management", 8<sup>th</sup> Ed., Vikas Publishing House, New Delhi.
2. Sharma R K, Gupta, Shashi K "Management Accounting", 9<sup>th</sup> revised edition, Kalayani Publishers, New Delhi.
3. James C Van Horne, "Financial Management and Policy" 11<sup>th</sup> edition, Prentice Hall of India
4. Fred R Kren, "Corporate Finance: Concepts and Policies", Blackwell Business, Oxford (UK)

**Introduction: Productivity**, definition and scope of motion and time study, history of motion and time study, work method design, human factor in the application of work study, man – machine interface.

**Activity charts:** operation process chart, flow chart, multiple activity charts, travel chart, flow diagram, and operation analysis.

**Motion study:** concept, micro motion study, memo motion study, cycle graphic and chronocyclegraphic analysis, fundamental hand motions, therbligs, micro motion study equipments, film analysis- SIMO charts, principles of motion economy.

**Time study:** concept, uses of time study, time study equipments, making the time study, work sampling, determination of sample size, procedure for selecting random observations, errors in work sampling.

**Rating factors and allowances:** the concept of qualified worker, the average worker, standard rating and standard performance, definition of rating, systems of rating, rating of efforts, scales of rating, introduction to allowances, classification of allowances, applying the allowances, determining the time standards, predetermining time standards (PTS), standard data, the uses of time standards, MTM-I, MTM-II.

**Principles of workplace design** physical requirements in the workplace anthropometrics and communication considerations, social requirements of the workplace- personal and territoriality considerations.

**Workspace design**, general principles, deciding position of control with respect to other controls, position of displays with respect to other displays, positioning of displays and controls, control display compatibility.

**Effect of environment** on work system design-noise, illumination, vibration, temperature and humidity.

**Recommended Books:**

1. Mark S.Sanders, and Ernest J.McCormick, —Human factors in Engineering and Design,McGraw Hill, New York.
2. Davind J.Oborne,||Ergonomics at Work,|| John willy and Sons Ltd., New York.
3. International Labour Organisation,||Introudction to Work Study,|| Universal Book Corporation, New Delhi.
4. Francis and White,||Facilities Location-an analytical approach,|| McGraw Hill, New York
5. R.S.Bridger,||Introduction to Ergonomics,|| McGraw Hill, New York.

**Introduction:** Concept of Occupational safety & Health, Importance of Occupational Safety & Health, Relationship between safety, health and productivity, Safety Triangle.

**Safety:** Influence of Plant layout & Design, Equipment Design, Workplace design on Safety, Industrial Accidents- types and causes, Cost of Accidents – Cost Analysis, Systems Safety Analysis- methods and Techniques.

**Noise & vibrations:** Physics of Sound, Physiology of Hearing, Acceptability Criterion, Noise Measurements, Control of Noise Exposure, Hearing Conservation Programs, Vibration in workplace- measurement & Control.

**Hot & Cold Environments:** Introduction, Physiology of Thermoregulation, Mechanisms of Thermal Exchange, Measuring Thermal Environment, Heat Stress Indices, Heat Exposure Limits, Assessing Environmental Strain, Controlling Thermal Exposure. Design of Local Exhaust system and general ventilation system.

**Industrial Illumination:** Need for lighting, relationship between illumination- safety, performance & Health. Natural & Artificial lighting sources, Characteristics of artificial lighting sources, quantity and quality of illumination, IES procedure for calculating optimum lighting requirement, recommended illumination standards for various industrial tasks.

**Books Recommended:**

1. Grimaldi J V, —Safety Management- 5th Edition, AITBS Publishers, Delhi, (2006).
2. McCormick J, —Human Factors in Engineering & Design- 7th Edition, McGraw Hill Publishing Company limited, (1992).
3. Salvator R Dinardi- Editor, —The Occupational Environment- Its Evaluation, Control and Management, AIHA Press, Fairfax, Virginia, (2003).
4. David Goetch, —The Safety and Health Handbook, Pearson Education, (1999).

**Introduction**

The concept, classification of machining processes, the benefits and limitations of advanced machining processes over conventional machining processes, why do we need advanced machining processes?

**Mechanical Advanced Machining Processes**

Abrasive Jet Machining ( AJM ): Introduction - Process, applications, advantages and disadvantages, variables in AJM like carrier gas, types of abrasives, grain size, jet velocity, work material, nozzle design etc., MRR in AJM, nozzle wear, jet cutting equipment, process details, practical applications.

Ultrasonic Machining (USM ) : Introduction - Process, elements of process, cutting tool system design, mechanics of cutting, effect of various parameters on MRR, applications of USM, limitations, recent developments.

Abrasive Flow Finishing (AFF): Working Principle, Abrasive Flow Machining System, Machine and Tooling, Process Variables, Process Performance, Applications

Magnetic Abrasive Finishing (MAF): Introduction, Working Principle of MAF, Material Removal (Or Stock Removal) and Surface Finish

Water Jet Cutting (WJC): Introduction, WJM Machine, Process Characteristics, Process Performance, applications

Abrasive Water Jet Machining (AWJM ) : Working Principle, AWJM Machine, Pumping System, Abrasive Feed System, Abrasive Jet Nozzle, Catcher, Process Characteristics, Abrasives, Abrasive Flow Rate, Abrasive Material, Cutting Parameters, Traverse Speed, Process Capabilities, Applications

**Thermoelectric Advanced Machining Processes**

Electric Discharge Machining (EDM ): Introduction, Working Principle Of EDM, R-C Pulse Generator, EDM Machine, Power Supply, Dielectric System, Electrodes, Servo System, Power delivered to the Discharging Circuit, Material Removal In RC Circuits, Surface Finish, Process Variables, Dielectric Pollution And Its Effects, Applications

Electric Discharge Grinding (EDG) And Electric Discharge Diamond Grinding (EDDG), Working Principle, Capabilities And Applications.

Wire Electric Discharge Machining : Working Principle, Wire EDM Machine, Dielectric System, Positioning System, Wire Drive System, Variables, Applications

Laser Beam Machining: Production Of Lasers, Working Principle Of Laser Beam Machining, Types of Lasers - Solid Lasers - Gas Lasers, Process Characteristics, Applications - Drilling - Cutting - Marking and miscellaneous Applications

Plasma Arc Machining: Working Principle, Plasma Arc Cutting System, Elements of a Plasma Arc Cutting System, Applications

Electron Beam Machining: Working Principle, Electron Beam Machining System, Electron Beam Gun, Vacuum System And Machining Chamber, Process Parameters, Applications

**Electrochemical and Chemical Advanced Machining Processes**

Electrochemical Machining: Introduction, Electrolysis, Electrochemical Machining (ECM) process, ECM Machine Tool - Power Source, Electrolyte Supply And Cleaning System, Tool And Tool Feed System, Work piece And Work Holding Device, Advantages And Limitations, Applications, Theory Of ECM - Faraday's Laws Of Electrolysis, Electrochemical Equivalent Of Alloys, Material Removal Rate In ECM, Self Regulating Feature - Maximum Permissible Feed Rate In ECM, Electrolyte Conductivity (K) - Temperature - Hydrogen Bubbles

Electrochemical Grinding: Introduction, ECG Machine Tool, Process Characteristics, Applications

Electrostream Drilling: Introduction, Process Performance

Electrochemical Deburring: Introduction - Types of Burrs, Basic Approach On Deburring, Classification of Deburring Processes, Electrochemical Deburring (ECDe) - Principle of Working, Applications, Specific Features Of ECDe Machine  
Chemical Machining (ChM) : Introduction, Maskants - Cut And Peel - Screen Printing - Photo-Resist Mask-Ant, Etchant, Advantages And Limitations

**Recommended Books**

1. Pandey and Shan, Modern Machining Processes, Tata McGraw Hill Publishing Company Limited New Delhi, 2004.
2. Serope Kalpakjian, Manufacturing Process for Engineering Materials, Addison - Wesley Publishing Company, 2002.
3. Ghosh and Malik, Manufacturing Science, Ease-West Press Private Limited New Delhi, 2006.
4. Jain V K, Advanced Machining Processes, Allied Publishers Private Limited New Delhi, 2004.
5. McGeough J A, Advanced Methods of Machining, Chapman and Hall Limited London, Springer International Edition 1988.
6. Hassan El-Hofy, Advanced Machining Processes, McGraw Hill New York, 2005.

**Introduction to Fracture Mechanics:** Stress-Strain Curve, Elements of dislocation theory, Historical perspective, Stress Concentration effect of flaws, Fracture Mechanics approach to design, Effect of material properties on fracture, Cleavage, Brittle and Ductile fracture, ductile brittle transition, modes of fracture failure,

**Linear Elastic Fracture Mechanics:** An atomic view of fracture, Griffith Energy Balance, Energy release rate, instability and the R Curves, compliance, tearing modulus, Stress and Displacement field in isotropic elastic materials, Airy stress function, Westergard approach for different modes of fracture, Stress analysis of crack, Stress intensity factor (SIF), relation between K and global behaviour, Effect of finite size, Experimental determination of Stress intensity factor

**Elastic-Plastic Fracture Mechanics:** Crack tip deformation and plastic zone size, plane stress vs plane strain, effective crack length, Irwin plastic zone correction, Dugdale approach, effect of plate thickness

J Contour Integral- Relevance and scope, J as a path-independent line integral, J as a stress intensity parameter, Stress-Strain relations, J-Controlled fracture, Laboratory measurement of J, Crack Tip Opening Displacement (CTOD), Relationship between CTOD, K and G, Equivalence between CTOD and J, Determination CTOD from strip yield model, HRR Singularity, Experimental determination of J-Integral and CTOD

## FATIGUE FRACTURE

**Fatigue Fracture:** Introduction to fatigue, factors affecting fatigue performance, fatigue loading, Characteristics of Fatigue Crack, Fatigue Crack Initiation: Effect of stress concentration on Fatigue crack initiation, Generalized equation for predicting the fatigue-crack-initiation threshold for steels, Methodology for predicting fatigue crack initiation from notches, Fatigue crack propagation Threshold, Constant Amplitude load fluctuation, Effect of mean stress, Effect of cyclic frequency and waveform, Fatigue and fracture behaviour of welded components

### Book Recommendations

1. Anderson T.L., Fracture Mechanics Fundamentals and Applications, CRC Press, Second edition 1994
2. Kumar Prashant, Elements of Fracture Mechanics, Wheelers Publishing Co. Ltd India, Second edition, 2010
3. Hertzberg Richard W., Deformation and Fracture Mechanics of Engineering Materials, Wiley India, Fourth Edition, 1996
4. Broek David, Elementary Engineering Fracture Mechanics, Kluwer Academic Publishers, Fourth revised reprint edition, 1999
5. Barsom John M. and Rolfe Stanley T., Fracture and Fatigue Control in Structures: Applications of Fracture Mechanics, ASTM USA, Third Edition, 1999
6. Sanford R.J., Principles of Fracture Mechanics, Printice Hall, Printice Hall USA, 2003
7. Gdoutos E.E., Rodopoulos C.A. and Yates J.R., Problems in Fracture Mechanics A Solution Guide, Kluwer Academic Publishers The Netherlands, 2003

Introduction, Development of MEMS Technology, Present, Future and Challenges, Fabrication Processes: Fundamentals of Material Science, Substrates: Single crystal substrates, Silicon on Insulator Substrate, Physical vapour deposition, Chemical vapour Deposition, Etching Processes, patterning, wafer bonding, annealing, chemical mechanical polishing, material doping, MEMS application in life sciences

Principal of Microsystems: Introduction, Micro-sensors and there types, Micro-actuation using different forces and materials, Micro-actuators and there types, Micro-accelerometers, Micro-fluidics

Scaling Laws in Miniaturization: Introduction to scaling, Scaling of physical systems scaling (geometric, mechanical, thermal, fluidic, electrical, optical and chemical and biological), computational fabrication, and material issues

Materials and Microsystems: Introduction, Substrates and wafers, active substrate materials, Silicon as a substrate material, Silicon compounds, silicon piezo resistors, Gallium Arsenide, Quarta, Piezoelectric crystals, polymers, packaging materials

Micro-system Fabrication Process and Manufacturing: Introduction, Photolithography, Ion implantation, Diffusion, Oxidation, Chemical vapour deposition, physical vapour deposition, Chemical Mechanical Polishing, Material Doping, Deposition of epitaxy, Etching, Patterning, wafer-bonding and annealing. Micro-manufacturing: Bulk micromachining, Surface micromachining, LIGA,

Packaging and Reliability: Packaging process steps, reliability models, MEMS failure mechanisms, Measurement Techniques for MEMS Operational, Reliability, and Failure Analysis Testing

## References

1. Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, Fourth reprint edition, 2012
2. Allen James J, Micro Electromechanical System Design, First edition, Taylor and Farancis, FL (USA), 2005
3. Maluf Nadim and Williams Kirt, An Introduction to Micro Electromechanical Systems Engineering, Second Edition, ARTECH House, MA (USA), 2004



### Section A

**Introduction:** Introduction to Human Factors Engineering, What is field of human factors, the scope of human factors, the study of human factors as a science, Historical evolution of ergonomics, ergonomics and human factors engineering, Goals of human factors engineering. Introduction to research methods, an overview of research methods, experimental research methods Experimental design.

**Auditory and Visual Sensory Systems:** Visual search, detection, discrimination. Auditory stimulus, Ear; the sensory transducer, the auditory experience, Alarms, criteria for alarms, designing for alarms, Sound localization, sound transmission problem, the speech signal, Speech Communications, hearing loss Noise reduction at the work place

### Section B

**Cognition:** Information processing models, selective attention, Reception, Human Factor Guidelines in perception, Working Memory, Human factors Implications of working memory Limits, Long term memory, Organisation of information in long term memory, episodic memory, Situation Awareness (SA), problem solving and troubleshooting.

**Displays & Controls:** classifications of displays, Thirteen principles of display design, Altering displays, labels, monitoring, multiple displays; display layouts, head up displays, configural displays, navigation displays and maps, Quantitative information displays. Controls; Principles of response selection, Discrete control activation, Positioning Control Devices, Verbal and symbolic inputs, Voice input, Continuous Control tracking, Control Order.

### Section C

**Engineering Anthropometry and Work place Design:** Human Variability and Statistics, anthropometric data, Structural and Functional data, Use of anthropometric data in design, General; Principles for workplace design; clearance requirement of the largest users, reach requirements of the smallest users, special requirements of maintenance people, adjustability requirements, visibility and normal line of sight, component arrangement, Design of standing and seated work areas, work surface; height, depth & inclination.

**Biomechanics of Work:** The musculoskeletal system, Biomechanical models, Low back problems, NOISH lifting guide, Manual material handling, Seated work and chair design, Upper extremities cumulative trauma disorders. Causes & prevention of CTD, hand tool design. Strain index method for DUE risk assessment. Work posture risk assessment using OWAS, Rapid Upper Limb Assessment and Rapid Entire Body Assessment tools.

**Work Physiology:** Muscle structure and metabolism, Circulatory and respiratory system, the respiratory system, Lung capacity, Lung capacity measurement using Spirometry. Measurement of workloads. Physical work capacity and whole body fatigue, causes and Control of whole body fatigue. Bio Energies. Stress and workloads. RSPM assessment.

### Books Recommended

1. Christopher D W, John D Lee. Gordon Becker, "*Human Factors Engineering*", PHI, 2011.
2. MI Khan, "*Industrial Ergonomics*", PHI, 2011.
3. Sanders Mark S and McCormick Ernert J, "*Human Factors in Engineering and Design*", McGraw- Hill Inc., 1993.
4. John B West, "*Respiratory Physiology*" Wolter Kulwer Lippincott Williams & Wilkins.

**Introduction to Global Energy Scenario :** Global Energy Requirements , Depletion of Conventional Energy Resources Availability of Non- Conventional Energy Sources, Fallouts of Energy Usage, Application of Carbon Credit.

**Energy Analysis and Thermodynamics :** Fundamentals of Thermodynamics (Relationship Between Heat and work) The First Law, The Second Law, Carnot Cycle, Rankine Cycle, Energy Balance ( Heat Balance for Steam Process), Energy Balance of Steam Generator.

**Energy Analysis of 'Real' Industrial Systems Factories:** Process System Optimization (Different states of Water and its Relationship with Pressure and Temperature, The Mollier Chart), Electrical System Optimization ( Electricity Rate Tariff, Key to Reduction in Electrical Energy Consumption, Methods to Improve Plant Power Factor, Load Management, Conduction Loss, Switching Loss, Magnetic Loss, Harmonics Compensation, Motor Control, Lighting Energy Saving, Other Energy Savings), Cogeneration (Theory and Practice, Cogeneration Technologies , Basic Thermodynamics Cycles), Heating Ventilation and Air Conditioning Systems ( Principles of Heat Pump, Liquid Chilling Units, Gas Cooling Technology, Air Conditioning Systems, Economizer Cycle, Heat Recovery System, Cold Storage), Principles of Heat Transfer (Modes of Heat Transfer, Conduction through a Flat Surface, Conduction through a Cylindrical Surface, Heat Transfer by Radiation, Heat Transfer by Convection, Finned-tube Heat Exchanger, Shell and Tube Heat Exchanger, Heat Loss from a Vessel or Tank).

**Energy Analysis of Real Industrial Systems Transportation Systems :** Energy Conservation in Transportation(Pattern of Energy Consumption, Emission Targets for Transportation ), New Technologies, Progress in Clean Diesel Technology (Areas of Improvement, Fuel, Engine, Exhaust Systems, Cleaning the Tail Pipe).

**Energy Analysis of Real Industrial Systems- Buildings:** Energy Consumption in Buildings , Construction Cost Vs Life Cycle Cost, Building Design- Walls and Roof , Heating Ventilation and Air Conditioning (HVAC) Systems, Water Supply Systems, Lighting Systems, Building Data Loggers and advanced Controls, The Energy Conservation Act 2001, National Building Code of India 2005.

**Principles And Objectives of Energy Management:** Introduction , Energy Planning , Energy Staffing, Energy Organisation , Energy Requirement, Energy Costing, Energy Budgeting, Energy Monitoring, Energy Consciousness Energy Conversions, Energy Efficient Equipment, Energy Management Professionals, Environment Pollution due to Energy Use ( Components of Pollution, Harmful Effects of Pollution, Measures Taken to Combat Pollution, Possible Future Measures) , Evaluation of alternative Energy Sources).

**Design of Energy Management Programmes :** Saving Energy and Implementation of Energy Conservation, Principles of Energy Management, Need for Energy Management Programme, Agenda for Organization Structure, Role of Energy Manager / Plant Engineer, Implement Energy Conservation Actions, Continuing Energy Conservation Efforts.

**Procedures for Energy Analysis and Audit:** Categories of Energy Audit, Types of Energy Audit, Ventilation Audit, Measuring and Detection Instruments for Energy Survey, Scope of Energy audit.

## References

1. Fay, James A. and Dan S. Golomb, Energy and The Environment, Oxford University Press, New York, 2002.
2. Mori, Y.H. and K. Ohnishi, Eds, Energy and Environment Technological Challenges for the Future, Springer-Verlag, New York, 2001.
3. Allenby, Braden, Technology and Environment in the Age of Humans, Island Press, Washington, D.C., 2005.
4. Jeong, Howon, Globalization and the Physical Environment, Chelsea House Publishers, Philadelphia, 2006.
5. Snedden, Robert, Energy Alternatives, Heinemann Library, Chicago, IL, 2002.
6. Nevena Lordanova, Ven. V. Venkatesau and Michael Calogero, World Engineering Congress.

