



ANNA UNIVERSITY
Chennai-25.
Syllabus for

M.E.(Full Time) Computer Integrated Manufacturing

MA147 Probability and Statistical Methods **3 1 0 4**

1. PROBABILITY AND RANDOM VARIABLES **12**

Probability - Random variables - Moments - Moment generating function - Standard distributions - Functions of random variables - Two dimensional R.Vs - Correlation and Regression.

2. ESTIMATION THEORY **8**

Principle of least squares - Regression - Multiple and partial correlations - Estimation of Parameters - Maximum likelihood estimates - Method of moments.

3. TESTING OF HYPOTHESIS **9**

Sampling distributions - Test based on Normal, t-distribution, Chi-square and F-distributions - Analysis of Variance - One way and Two way classifications.

4. DESIGN OF EXPERIMENTS **9**

Completely Randomized Design - Randomized Block design - Latin square design - 2 Factorial Design.

5. TIME SERIES **7**

Characteristics and Representation - Moving Averages - Exponential smoothing - Auto Regressive Processes.

Total No of periods: 45

References:

1. *Fruend John, E. and Miller, Irwin , " Probability and Statistics for Engineering " , 5th Edition, Prentice Hall, 1994.*
2. *Jay, L. Devore, " Probability and Statistics for Engineering and Sciences " , Brooks/Cole Publishing Company Monterey, California, 1982.*
3. *Montgomery D.C and Johnson,L.A.," Forecasting and Time Series " , McGraw-Hill.*
4. *Anderson, O.D., " Time Series Analysis: Theory and practice " , I.North - Holland, Amsterdam, 1982.*
5. *Gupta, S.C. and Kapur, V.K." Fundamentals of Mathematical Statistics " , Sultan Chand and Sons, New Delhi, 1999.*

Web Referenecs:

1. www.maths.adelaide.edu.AU/Applied/Courses/Hps.html.
2. www.cs.cf.ac.UK/Dave/A12/nodes86.html.

1. INTRODUCTION 5

The evolution of order policies, from MRP to MRP II, the role of Production organization, Operations control.

2. DATABASE 7

Terminologies - Entities and attributes - Data models, schema and subschema - Data Independence - ER Diagram - Trends in database.

3. DESIGNING DATABASE 13

Hierarchical model - Network approach - Relational Data model -concepts, principles, keys, relational operations - functional dependence -Normalisation, types - Query languages.

4. MANUFACTURING CONSIDERATION 10

The product and its structure, Inventory and process flow - Shop floor control - Data structure and procedure - various model - the order scheduling module, input / output analysis module the stock status database - the complete IOM database.

5. INFORMATION SYSTEM FOR MANUFACTURING 10

Parts oriented production information system - concepts and structure -computerised production scheduling, on-line production control systems, Computer based production management system, computerised manufacturing information system - case study.

Total No of periods: 45

References:

1. Luca G. Sartori, " *Manufacturing Information Systems* ", Addison-Wesley Publishing Company, 1988.
2. Date.C.J., " *An Introduction to Database systems* ", Narosa Publishing House, 1997.
3. Orlicky.G., " *Material Requirements Planning* ", McGraw-Hill Publishing Co., 1975.
4. Kerr.R, " *Knowledge based Manufacturing Management* ", Addison-wesley, 1991.

Web Reference:

1. www.ist.psu.edu

1. CAD / CAM HARDWARE / SOFTWARE 7

Types of Computer systems - Input devices - Output devices - CAD/CAM Software - Graphics standards - Basic Definitions Modes of Graphics Operations -User Interface - Software modules- Modelling and Viewing - Software Development - Efficient use of CAD/CAM Software - Microcomputer based CAD/CAM.

2. TWO DIMENSIONAL AND THREE DIMENSIONAL TRANSFORMATIONS 10

2D - Representation and Transformation of Points - Transformation of Lines -Rotation, Reflection, Scaling and combined transformations - 3Dscaling - shearing - Rotation - Reflection - Translation - Projections parametric representation of Ellipse, Parabola, Hyperbola.

3. MODELLING AND ANALYSIS 8

Wire frame, Surface and Solid modelling - Solid modelling packages - Finite Element Analysis (FEA) - Introduction and procedures - Solution Techniques - Introduction to FEA packages.

4. COMPUTER AIDED MANUFACTURE 10

Manufacturing Planning and Control - CAD/CAM Integration - Principles of Computer Integrated Manufacturing - Hierarchical Network of Computers - Local Area Networks - Process Planning - Computer Aided Process Planning - Retrieval and Generative approaches.

5. PRODUCTION PLANNING AND SHOP FLOOR CONTROL 10

Computer Integrated Production Management System - Master Production Schedule - Material Requirement Planning - Inventory Management - Manufacturing and Design Data Base - Capacity Planning - Shop Floor Control - Functions - Order release - Order Scheduling - Order progress - Factory data collection.

Total No of periods: 45

References:

1. Ibrahim Zeid, CAD/CAM, " Theory and Practaice ", Tata McGraw-Hill Ed., 1998.
2. David F.Rogers and Alan Adams.J, " Mathematical Elements for Computer Graphics ", McGraw-Hill Publishing Company International Edition, 1990.
3. William M.Newman, Robert F.Sproull, " Principles of Interactive Computer Graphics ", McGraw-Hill International Book Company, 1984.
4. Groover M.P., Automation, " Production Systems and Computer Integrated Manufacturing ", Prentice-Hall of India Pvt.Ltd., New Delhi, 1996.
5. Paul G.Ranky, " Computer Integrated Manufacture ", Prentice-Hall International, UK, 1986.

Web References:

1. www.CADCAM-magazine.CO.UK.
2. www.compinfo-center.com/compinfo/tt.nsf.
3. www.delcom.com

1. ELASTIC AND PLASTIC BEHAVIOUR 10

Elasticity in metals and polymers - Mechanism of plastic deformation, role of dislocations, yield stress, shear strength of perfect and real crystals - Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour - Super plasticity - Deformation of non crystalline material.

2. FRACTURE BEHAVIOUR 10

Griffith's theory, stress intensity factor and fracture toughness - Toughening mechanisms - Ductile, brittle transition in steel - High temperature fracture, creep - Larson-Miller parameter - Deformation and fracture mechanism maps - Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law - Effect of surface and metallurgical parameters on fatigue - Fracture of non metallic materials - Failure analysis, sources of failure, procedure of failure analysis.

3. SELECTION OF MATERIALS 10

Motivation for selection, cost basis and service requirements - Selection for mechanical properties, strength, toughness, fatigue and creep - Selection for surface durability corrosion and wear resistance - Relationship between materials selection and processing - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

4. MODERN METALLIC MATERIALS 8

Dual phase steels, Micro alloyed, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) steel, Maraging steel - Intermetallics, Ni and Ti aluminides - Smart materials, shape memory alloys - Metallic glass - Quasi crystal and nano crystalline materials.

5. NON METALLIC MATERIALS 7

Polymeric materials - Formation of polymer structure - Production techniques of fibres, foams, adhesives and coatings - Structure, properties and applications of engineering polymers - Advanced structural ceramics, WC, TiC, TaC, Al₂O₃, SiC, Si₃N₄, CBN and diamond - properties, processing and applications.

Total No of periods: 45

References:

1. *Thomas H.Courtney, " Mechanical Behaviour of Materials ", (2nd Edition), McGraw-Hill, 2000.*
2. *Charles J.A., Crane, F.A.A and Furness, J.A.G., " Selection and use of Engineering Materials ", (3rd Edition), Butterworth-Heiremann, 1977.*
3. *Flinn, R.A. and Trojan, P.K., " Engineering Materials and their Applications ", (4th Edition), Jaico, 1999.*
4. *George E.Dieter, " Mechanical Metallurgy ", McGraw Hill, 1988.*
5. *Metals Hand Book, Vol.10, " Failure Analysis and Prevention ", (10th Edition), 1994.*

Web References:

1. www.astm.org/labs/pages/131350.htm
2. www.appliedmaterials.com/carrers/agu-ei.html.

1. INTRODUCTION TO CNC MACHINE TOOLS 7

Development of CNC Technology, principles, features, advantages, economic benefits, applications, CNC, DNC concept, classification of CNC Machine, types of control, CNC controllers, characteristics, interpolators.

2. STRUCTURE OF CNC MACHINE TOOL 9

CNC Machine building, structural details, configuration and design, guideways - friction and anti friction and other types of guide ways, elements used to convert the rotary motion to a linear motion - Screw and nut, recirculating ball screw, planetary roller screw, recirculating roller screw, rack and pinion, torque transmission elements - gears, timing belts, flexible couplings, Bearings.

3. DRIVES AND CONTROLS 9

Spindle drives - DC shunt motor, 3 phase AC induction motor, feed drives - stepper motor, servo principle, DC & AC servomotors. Open loop and closed loop control, Axis measuring system - synchro, synchro-resolver, gratings, moire fringe gratings, encoders, inductosyn, laser interferometer.

4. CNC PROGRAMMING 10

Coordinate system, structure of a part program, G & M Codes, Manual part programming for Fanuc, Heidenhain, Sinumeric control system, CAPP, APT part programming using CAD/CAM, Parametric Programming.

5. TOOLING AND MAINTENANCE OF CNC 10

Cutting tool materials, carbide insets classification, qualified, semi qualified and preset tooling, tooling system for Machining centre and Turning centre, work holding devices, maintenance of CNC Machines.

Total No of periods: 45

Text Book:

1. *HMT, Mechatronics, Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.*

References:

1. *James Madison, " CNC Machining Hand Book ", Industrial Press Inc., 1996.*
2. *Steve Krar, Arthur Gill, " CNC Technology and Programming ", McGraw-Hill International Editions, 1990.*
3. *Berry Leathan - Jones, " Introduction to Computer Numerical Control ", Pitman, London, 1987.*
4. *Hans B.Kief, T.Fredericx Waters, " Computer Numerical Control ", MacMillan / McGraw-Hill, 1992.*
5. *Bernard Hodgers, " CNC Part Programming Work Book ", city and Guids / Macmillan, 1994.*
6. *David Gribbs, " An Introduction to CNC Machining ", Cassell, 1987.*
7. *Sadasivan, T.A. and Sarathy, D, " Cutting Tools for Productive Machining ", Widia (India) Ltd., August 1999.*
8. *Radhakrishnan, P. " Computer Numerical Control Machines ", New Central Book Agency, 1992.*
9. *Peter Smid, " CNC Programming Hand Book ", Industrial Press Inc., 2000.*

Web References:

1. <http://liesu5.ieem.ust.hk/dfaculty/ajay/courses/ieem215/lecs/CNC.html>
2. <http://CNC-router-laser-machine.com/machinery.html>

60

Computer Aided Drafting - Operating Systems - Wire Frame, Surface and Solid Modelling Simulation and Machining using CNC/DNC Machine Tools -Use of FEM packages - Relational Data Bases - Networking - Practice on Computer Aided Measuring Instruments - Image Processing - Software Development for Manufacturing - CNC Controllers - Use of advanced CNC Machine Packages - Business Data Processing.

Total No of periods: 60

Web Reference:

1. <http://www.mie.utoronto.ca/labs/ciml/cimhone.html>.

1. INTRODUCTION 3

Systems, modeling, general systems theory, concept of simulation, simulation as a decision making tool, types of simulation.

2. RANDOM NUMBERS 5

Pseudo random numbers, methods of generating random variates, discrete and continuous distributions, testing of random numbers.

3. DESIGN OF SIMULATION EXPERIMENTS 8

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation validation.

4. SIMULATION LANGUAGES 14

Comparison and selection of simulation languages, study of any one simulation language.

5. CASE STUDIES/MINI PROJECT 15

Development of simulation models using the simulation language studied for systems like, queuing systems, production systems, Inventory systems, maintenance and replacement systems, investment analysis and network.

Total No of periods: 45

References:

1. *Jerry Banks and John S. Carson, Barry L. Nelson, David M. Nicol, " Discrete event system simulation ", Prentice Hall, India, 2000.*
2. *Shannon, R.E. Systems simulation, " The art and science ", Prentice Hall, 1975.*
3. *Thomas J. Schriber, " Simulation using GPSS ", John Wiley, 1991.*

PE141 Flexible Competitive Manufacturing System

3 0 0 3

1. MANUFACTURING IN A COMPETITIVE ENVIRONMENT 9

Automation of manufacturing process - Numerical control - Adaptive control - material handling and movement - Industrial robots - Sensor technology - flexible, fixturing - Design for assembly, disassembly and service.

2. GROUP TECHNOLOGY 9

Part families - classification and coding - Production flow analysis - Machine cell design - Benefits.

3. FLEXIBLE MANUFACTURING SYSTEMS 9

Introduction - Components of FMS - Application work stations - Computer control and functions - Planning, scheduling and control of FMS - Scheduling - Knowledge based scheduling - Hierarchy of computer control - Supervisory computer.

4. COMPUTER SOFTWARE, SIMULATION AND DATABASE OF FMS 9

System issues - Types of software - specification and selection - Trends - Application of simulation - software - Manufacturing data systems - data flow - CAD/CAM considerations - Planning FMS database.

5. JUST IN TIME 9

Characteristics of JIT - Pull method - quality -small lot sizes - work station loads - close supplier ties - flexible work force - line flow strategy - preventive maintenance - Karban system - strategic implications - implementation issues - MRD JIT - Lean manufacture.

Total No of periods: 45

References:

1. *Groover M.P., " Automation, Production Systems and Computer Integrated Manufacturing ", Prentice-Hall of India Pvt. Ltd., New Delhi, 1996.*
2. *Jha, N.K. " Handbook of Flexible Manufacturing Systems ", Academic Press Inc., 1991.*
3. *Kalpakjian, " Manufacturing Engineering and Technology ", Addison-Wesley Publishing Co., 1995.*
4. *Taiichi Ohno, Toyota, " Production System Beyond Large-Scale production ", Productivity Press (India) Pvt.Ltd., 1992.*

Web Reference:

1. <http://www.engineeringtalk.com/news/lvd103.htm>

1. DEMAND FORECASTING 10

Characteristics and Principles, Methods, Qualitative Methods - Delphi technique, Market Research, Intrinsic method-time-series analysis, moving averages, exponential smoothing - The Bon Jenkins method, Extrinsic methods - Regression modls, measurement of forecast errors.

Characteristics and Principles, Methods, Qualitative Methods - Delphi technique, Market Reasearch, Intrinsic methods - time-series analysis, moving averages, exponential smoothing - The Bon Jenkins method, Extrinsic methods - Regression models, measurement of forecast errors.

2. INVENTORY MANAGEMENT 10

Functions of inventory - Objectives - Inventory systems - Inventory models - Basic and advanced inventory models.

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3. PRODUCTION PLANNING 10

Purpose, Characteristics - Aggregate Planning - Methods - Master Production Scheduling - functions - Time buckets - time fences - Orders - Reports.

Purpose, Characteristics - Aggregate Planning - Methods - Master Production scheduling - functions - Time buckets -time fences - Orders - Reports.

4. MATERIALS, REQUIREMENT PLANNING AND CAPACITY PLANNING 10

Purpose of MRP - Inputs to MRP - MRP LOGIC - Planning Factors - Outputs from MRP - Resource Planning - Capacity Planning.

Purpose of MRP - Inputs to MRP - MRP LOGIC - Planning factors - Outputs from MRP - Resource Planning - Capacity Planning.

5. CURRENT TRENDS 5

JIT, Supply Chain Management - Concurrent Engineering, MRP II, ERP.

JIT, Supply Chain Management - Concurrent Engineering, MRP II, LERP.

Total No of periods: 45

References:

1. Lee J.Krajewski, Larry P.Ritzman, " *Operations Management Strategy and Analysis Addison* " - Wesley, 1999.
2. Spencer B.Smith, " *Computer Based Production and Inventory Control* ", Prentice Hall, 1989.
3. Joseph S.Martinkh, " *Production and Operations Management* ", John wiley & sons, 1999.
4. Joseph Monks, " *Operations Management* ", Theory and Practical, McGraw-Hill Publishing Company, 1987.
5. Nanu Singh, " *Systems approach to computer-integrated design and Manufacturing* ", John Wiley & Sons, 1996.

Web Reference:

1. <http://www.genex.co.th/Tech-update/DNS/scena102.htm>

1. MEASURING MACHINES 9

Tool Maker's microscope - Co-ordinate measuring machines - Universal measuring machine - Laser viewers for production profile checks - Image shearing microscope - Use of computers - Machine vision technology - Microprocessors in metrology.

2. STATISTICAL QUALITY CONTROL 9

Data presentation - Statistical measures and tools - Process capability - Confidence and tolerance limits - Control charts for variables and for fraction defectives - Theory of probability - Sampling - ABC standard - Reliability and life testing.

3. LIQUID PENETRANT AND MAGNETIC PARTICLE TESTS 9

Characteristics of liquid penetrants - different washable systems - Developers - applications - Methods of production of magnetic fields - Principles of operation of magnetic particle test - Applications - Advantages and limitations.

4. RADIOGRAPHY 9

Sources of ray-x-ray production - properties of d and x rays - film characteristics - exposure charts - contrasts - operational characteristics of x ray equipment - applications.

5. ULTRASONIC AND ACOUSTIC EMISSION TECHNIQUES 9

Production of ultrasonic waves - different types of waves - general characteristics of waves - pulse echo method - A, B, C scans - Principles of acoustic emission techniques - Advantages and limitations - Instrumentation - applications.

Total No of periods: 45

References:

1. *JAIN, R.K. " Engineering Metrology ", Khanna Publishers, 1997.*
2. *Barry Hull and Vernon John, " Non Destructive Testing ", MacMillan, 1988.*
3. *American Society for Metals, " Metals Hand Book ", Vol.II, 1976.*
4. *Progress in Acoustic Emission, " Proceedings of 10th International Acoustic Emission Symposium ", Japanese Society for NDI, 1990.*

Web References:

1. *www.metrologytooling.com*
2. *www.sisndt.com*
3. *www.iuk'tu-harburg.de*

1. OIL HYDRAULIC SYSTEMS 2

Hydraulic Power Generators - Selection and specification of pumps, pump characteristics.

2. HYDRAULIC ACTUATORS 2

Linear and Rotary Actuators - selection, specification and characteristics.

3. CONTROL AND REGULATION ELEMENTS 12

Pressure - direction and flow control valves - relief valves, non return and safety valves - actuation systems.

4. HYDRAULIC CIRCUITS 4

Reciprocation, quick return, sequencing, synchronising circuits - accumulator circuits - industrial circuits - press circuits - hydraulic milling machine - grinding, planning, copying, forklift, earth mover circuits - design and selection of components - safety and emergency mandrels.

5. PNEUMATIC SYSTEMS AND CIRCUITS 18

Pneumatic fundamentals - control elements, position and pressure sensing -logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods - step counter method - compound circuit design - combination circuit design.

6. INSTALLATION, MAINTENANCE AND SPECIAL CIRCUITS 7

Pneumatic equipments - selection of components - design calculations -application - fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

Total No of periods: 45

References:

1. *Antony Esposito, " Fluid power with Applications ", Prentice Hall, 1980.*
2. *Dudley, A.Pease and John J.Pippenger, " Basic Fluid Power ", Prentice Hall, 1987.*
3. *Andrew Parr, " Hydraulic and Pneumatics ", (HB), Jaico Publishing House, 1999.*
4. *Bolton. W. " Pneumatic and Hydraulic Systems ", Butterworth - Heineman, 1997.*

Web References:

1. *www.pneumatics.com*
2. *www.fluidpower.com.tw*

1. INTRODUCTION 5

Productivity concepts - Macro and Micro factors of productivity, Productivity benefit model, productivity cycle.

2. PRODUCTIVITY MODELS 12

Productivity measurement at International, National and Organisational level, Total productivity models. Productivity management in manufacturing and service sector. Productivity evaluation models, Productivity improvement models and techniques.

3. ORGANISATIONAL TRANSFORMATION 8

Principles of organisational transformation and re-engineering, fundamentals of process reengineering, preparing the workforce for transformation and reengineering, methodology, guidelines, DSMCQ and PMP model.

4. RE-ENGINEERING PROCESS IMPROVEMENT MODELS 10

PMI models, Edosomwan model, Moen and Nolan strategy for process improvement, LMICIP model, NPRDC model.

5. RE-ENGINEERING TOOLS AND IMPLEMENTATION 10

Analytical and process tools and techniques - Information and communication technology - Enabling role of IT, RE-opportunities, process redesign - cases. Software methods in BPR - specification of BP, case study - Order, processing, user interfaces, maintainability and reusability.

Total No of periods: 45

References:

1. Sumanth, D.J., " *Productivity engineering and management* ", TMH, New Delhi, 1990.
2. Edosomwan, J.A., " *Organisational transformation and process re-engineering* ",
British Library cataloging in pub. data, 1996.
3. Rastogi, P.N. " *Re-Engineering and Re-inventing the enterprise* ", Wheeler pub. New Delhi, 1995.
4. Premvrat, Sardana, G.D. and Sahay, B.S, " *Productivity Management - A systems approach* ",
Narosa Pub. New Delhi, 1998.

ID044 Supply Chain Management

3 0 0 3

1. INTRODUCTION 5

Logistics - Concepts, Definitions, approaches, factors affecting logistics. Supply chain - basic tasks of the supply chain - the new corporate model.

2. SUPPLY CHAIN MANAGEMENT 10

The new paradigm, the modular company, the network relations, supply process, Procurement process - Distribution management.

3. EVOLUTION OF SUPPLY CHAIN MODELS 10

Strategy and structure - factors of supply chain - Manufacturing strategy stages, supply chain progress - model for competing through supply chain management - PLC grid, supply chain redesign - Linking supply chain with customer.

4. SUPPLY CHAIN ACTIVITY SYSTEMS 10

Structuring the SC, SC and new products, functional roles in SC, SC design frame-work, collaborative product commerce (CPC).

5. SCM ORGANISATION AND INFORMATION SYSTEM 10

The management task, logistics organisation, the logistics information systems -Topology of SC application - MRP, ERP, Warehouse management system, product data management - cases.

Total No of periods: 45

References:

1. Scharj, P.B., Lasen, T.S., " *Managing the global supply chain* ", Viva books, New Delhi, 2000.
2. Ayers, J.B., " *Hand book of supply chain management* ", The St. Lencie press, 2000.
3. Nicolas, J.N., " *Competeive manufacturing management-continuous improvement* ",
Lean production, customer focused quality, McGraw-Hill, NY, 1998.
4. Steudel, H.J. and Desruelle, P., " *Manufacturing in the nineties-How to become a mean, lean and world class competitor* ", Van Nostrand Reinhold, NY, 1992.

- 1. INTRODUCTION 5**
Introduction to Group Technology, Limitations of traditional manufacturing systems, characteristics and design of groups, benefits of GT and issues in GT.
- 2. CMS PLANNING AND DESIGN 12**
Problems in GT/CMS - Design of CMS - Models, traditional approaches and non-traditional approaches - Genetic Algorithms, Simulated Annealing, Neural networks.
- 3. IMPLEMENTATION OF GT/CMS 10**
Inter and Intra cell layout, cost and non-cost based models, establishing a team approach, Managerial structure and groups, batch sequencing and sizing, life cycle issues in GT/CMS.
- 4. PERFORMANCE MEASUREMENT AND CONTROL 10**
Measuring CMS performance - Parametric analysis - PBC in GT/CMS, cell loading, GT and MRP - framework.
- 5. ECONOMICS OF GT/CMS 8**
Conventional Vs group use of computer models in GT/CMS, Human aspects of GT/CMS - cases.

Total No of periods: 45

References:

1. Burbidge, J.L. Group " *Technology in Engineering Industry* ", Mechanical Engineering pub. London, 1979.
2. Askin, R.G. and Vakharia, A.J., G.T " *Planning and Operation, in The automated factory-Hand Book: Technology and Management* ", Cleland, D.I. and Bidananda, B (Eds), TAB Books, NY, 1991.
3. Irani, S.A. " *Cellular Manufacturing Systems* ", Hand Book.
4. Kamrani, A.K, Parsaei, H.R and Liles, D.H. (Eds), " *planning, design and analysis of cellular manufacturing systems* ", Elsevier, 1995.

1. STRESS AND STRAIN 10

Three dimensional stress pattern-true stress and true strain-Principal stresses-Yield criteria-Vos Mises criterion-Tresca's criterion-Von Mises Yield for plane strain Problems-Coloumb function and sticking friction.

2. FORGING 9

Forging in Plane strain - Forging of circular disc - Effect of friction - Forging equipment - defects in forged products-Causes & Remedies.

3. ROLLING AND EXTRUSION 8

Rolling of sheet and strip in plane strain conditions - Effect of friction -maximum draft, rolling load, torque and H.P. - roll deflection - defect in rolled products - causes and remedies - forward and backward extrusion - Approximate extrusion loads - tube extrusion.

4. DRAWING 9

Rod and Wire drawing - Equilibrium equation - Strip drawing - tube drawing with out mandrel - Tube drawing with mandrel - Effect of friction and cone angle - Deflect in drawn parts.

5. UNCONVENTIONAL FORMING 9

High energy rate forming - Explosive forming - Magnetic Pulse forming -Electro hydraulic forming - Superplasticity - Powder metallurgy - Techniques - Applications.

Total No of periods: 45

References:

1. Rao, P.N. " *Manufacturing Technology* ", Tata McGraw-Hill, 1991.
2. Avitzur, " *Metal Forming Processes and Analysis* ", McGraw-Hill, 1991.
3. Dieter, " *Mechanical Metallurgy* ", McGraw-Hill, 1996.
4. Harris, J.N., " *Mechanical working of Metals* ", Theory and Practice, Pergamon Press, 1995.
5. Taylour Altan, Soo-Ik-Oh and Harold L. Gegel - " *Americal Society for Metals* ", 1983.

Web References:

1. www.kkai.com/matproc.html

1. WELDING METALLURGY 10

Weld thermal cycles - Heat Affected Zone (HAZ) - Weldability of steels - Cast iron - Stainless steels, aluminium, copper and titanium alloys - Hydrogen embrittlement - Pro and Post weld heat treatments - Weld defects.

2. WELDING OF DISSIMILAR METALS 10

Friction welding process - effects of speed and pressure - explosive welding -plasma arc welding - Electron beam welding - High frequency induction welding - Diffusion bonding - Cold pressure welding - Ultrasonic welding - Laser beam welding.

3. SAND CASTING 8

Patterns - Moulding processes materials - Moulding processes equipment and mechanism - Molding sands - Cores - Core materials - Solidification of metals - Pouring and feeding of castings.

4. NON FERROUS CASTINGS 8

Aluminium and Magnesium Foundry practice - Aluminium and Magnesium casting alloys - Copper alloy foundry - Copper-base casting alloys

5. FERROUS CASTINGS 9

Steel castings - The family of cast iron - Melting of steels and cast irons - Grey iron foundry practice - Ductile iron - Malleable iron casting design considerations.

Total No of periods: 45

References:

1. Heine, Loper and Rosenthal, " *Principles of Metal casting* ", Tata McGraw-Hill, 1994.
2. American Society of Metals, " *Source Book on Electron beam and laser beam welding* ", 1987.
3. American Society of Metals, " *Metals Hand Book* ", 9th Edition, Vol.V, 1989.
4. American Society of Welding, " *Hand book of Welding* ", Vol.I to V.

Web References:

1. [www.technanalysis.com/die CAS](http://www.technanalysis.com/die_CAS)
2. www.manufacturing.net/magazine/purchasing/archives/1999/purl216-99/121mnew.htm

References:

1. Reddy, J.N. " *An Introduction to the Finite Element Method* ", McGraw-Hill, 1985.
2. Rao, S.S., " *Finite Element Method in Engineering* ", Pergammon Press, 1989.
3. Bathe, K.J., " *Finite Element Procedures in Engineering Analysis*, 1990.
4. Kobayashi, S, Soo-Ik-Oh and Altan, T, " *Metal Forming and the Finite Element Methods* ", Oxford University Press, 1989.
5. Lewis R.W., Morgan, K, Thomas, H.R., and Seetharaman, K.N., " *The Finite Element Method in Heat Transfer Analysis* ", JohnWiley, 1994.

Web References:

1. www.tbook.com
2. www.pollockeng.com

PE035 Reliability and Total Productive Maintenance

3 0 0 3

1. INTRODUCTION 10

Reliability function - MTBF - MTTF - mortality curve - availability -Maintainability.

2. FAILURE DATA ANALYSIS 8

Repair time distributions - exponential, normal, log normal, gamma, and Weibull - reliability data requirements - Graphical evaluation.

3. RELIABILITY PREDICTION 12

Failure rate estimates - Effect of environment and stress - Series and Parallel systems - RDB analysis - Standby Systems - Complex Systems.

4. RELIABILITY MANAGEMENT 5

Reliability demonstration testing - Reliability growth testing - Duane curve -Risk assessment - FMEA, Fault tree.

5. TOTAL PRODUCTIVE MAINTENANCE 10

Causes of Machine Fialures - Downtime - Maintenance policies - Restorability predictions - Replacement models - Spares provisioning -Maintenance management - Cleanliness and House Keeping.

Total No of periods: 45

References:

1. *Paul Kales, Reliability for technology, " Engineering and Management ", Prentice Hall, New Jersey, 1998.*
2. *Modarres, " Reliability and Risk Analysis ", Meral Dekker Inc., 1993.*
3. *Gopalakrishnan.P, and Banerji A.K., " Maintenance and Spare Parts Management ", Prentice Hall of India, New Delhi, 1996.*

1. INTRODUCTION 3

Introduction to Mechatronics - Systems - Mechatronics in Products - Measurement Systems - Control Systems - Traditional design and Mechatronics Design.

2. SENSORS AND TRANSDUCERS 12

Introduction - Performance Terminology - Displacement, Position and Proximity - Velocity and Motion - Fluid pressure - Temperature sensors - Light sensors - Selection of sensors - Signal processing - Servo systems.

3. MICROPROCESSORS IN MECHATRONICS 15

Introduction - Architecture - Pin configuration - Instruction set - Programming of Microprocessors using 8085 instructions - Interfacing input and output devices - Interfacing D/A converters and A/D converters - Applications - Temperature control - Stepper motor control - Traffic light controller.

4. PROGRAMMABLE LOGIC CONTROLLERS 8

Introduction - Basic structure - Input / Output processing - Programming - Mnemonics Timers, Internal relays and counters - Data handling - Analog input / output - Selection of PLC.

5. DESIGN AND MECHATRONICS 7

Designing - Possible design solutions - Case studies of Mechatronics systems.

Total No of periods: 45

Text Books:

1. *Michael B.Histand and David G. Alciatore, " Introduction to Mechatronics and Measurement Systems", McGraw-Hill International Editions, 1999.*
2. *Bradley, D.A., Dawson, D, Buru, N.C. and Loader, A.J., " Mechatronics ", Chapman and Hall, 1993.*
3. *Ramesh.S, Gaonkar, " Microprocessor Architecture, Programming and Applications ", Wiley Eastern, 1998.*
4. *Lawrence J.Kamm, " Understanding Electro-Mechanical Engineering, An Introduction to Mechatronics ", Prentice-Hall, 2000.*
5. *Ghosh, P.K. and Sridhar, P.R., 0000 to 8085, " Introduction to Microprocessors for Engineers and Scientists ", Second Edition, Prentice Hall, 1995.*

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1. *www.cs. indiana.edu.*

1. COMPUTER BASED INFORMATION SYSTEM 7

Concept of Information and System - system classification - The challenge of information system - Computers and information processing - managing data resource - organizing data in a traditional file environment - a modern database environment - designing database.

2. MANAGEMENT INFORMATION SYSTEM 10

Concepts - Design and implementation of MIS - Information system for decision making, types and levels of decision making - MIS as a technique for making programmed decisions - Decision - Assisting information systems - Conceptual system design - detailed system design.

3. OVERVIEW OF SYSTEM DEVELOPMENT 10

System analysis - System Design - completing the system development process - the traditional system life cycle - Stages and limitations of life cycle approach - case study.

4. QUALITY, SUCCESS AND SERVICES 10

Traditional tool and Methodologies for quality assurances - New approaches to quality - Information system failure causes - the concept of implementation - controlling risk factor.

5. KNOWLEDGE - BASED SYSTEMS 8

Decision Support Systems - Group DSS - ESS - Artificial Intelligence - Expert System - Other intelligent technique - Neural network, Genetic Algorithm, Fuzzy Logic.

Total No of periods: 45

References:

1. *Kenneth C.Laudon and Jane P.Laudon, " Management Information systems ", Prentice Hall of India Pvt., Ltd., 2000.*
2. *Robert G.Mudrick, Joel E.Ross and James R.Clagget, " Information system for Modern Management ", Prentice Hall of India Pvt., Ltd., 1995.*
3. *Davis.G.B., MIS, " Conceptual Foundation, Structure and Development " McGraw-Hill Publishing Co., 1974.*
4. *Chung.P.W.H. and Lovegrove G., " Industrial and Engineering Application of AI and Expert systems ", Gardon Breach Science Publication, 1993.*

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Total No of periods: 45

1. INTRODUCTION 5

The Place of Process Planning in the Manufacturing cycle - Process Planning and Production Planning - Process Planning and Concurrent Engineering, CAPP, Group Technology.

2. PART DESIGN REPRESENTATION 10

Design Drafting - Dimensioning - Conventional tolerancing - Geometric tolerancing - CAD - input / output devices - topology - Geometric transformation - Perspective transformation - Data structure - Geometric modelling for process planning - GT coding - The optiz system - The MICLASS system.

3. PROCESS ENGINEERING AND PROCESS PLANNING 10

Experienced, based planning - Decision table and decision trees - Process capability analysis - Process Planning - Variant process planning - Generative approach - Forward and Backward planning, Input format, AI.

4. COMPUTER AIDED PROCESS PLANNING SYSTEMS 10

Logical Design of a Process Planning - Implementation considerations - manufacturing system components, production Volume, No. of production families - CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.

5. AN INTERGARTED PROCESS PLANNING SYSTEMS 10

Totally intergated process planning systems - An Overview - Modulus structure - Data Structure, operation - Report Generation, Expert process planning.

Total No of periods: 45

References:

1. *Gideon Halevi and Roland D. Weill, " Principles of Process Planning ", A logical approach, Chapman & Hall, 1995.*
2. *Tien-Chien Chang, Richard A.Wysk, "An Introduction to automated process planning systems ", Prentice Hall, 1985.*
3. *Chang, T.C., " An Expert Process Planning System ", Prentice Hall, 1985.*
4. *Nanua Singh, " Systems Approach to Computer Intergrated Design and Manufacturing ", John Wiley & Sons, 1996.*
5. *Rao, " Computer Aided Mnuufacturing ", Tata McGraw Hill Publishing Co., 2000.*

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1. <http://claymore.engineer.gusu.edu/jackh/eod/automate/capp/capp.htm>
2. <http://Estraj.ute.sk/journal/engl/027/027.htm>

1. INTRODUCTION 9

Basic concepts - Robot anatomy - Robot configurations - Basic robot motions - Types of drives - Applications - Material handling - processing -Assembly and Inspection - safety considerations.

2. TRANSFORMATIONS AND KINEMATICS 9

Vector operations - Translational transformations and Rotational transformations - Properties of transformation matrices-Homogeneous transformations and Manipulator - Forward solution - Inverse solution.

3. CONTROLS AND END EFFECTORS 9

Control system concepts - Analysis - control of joints - Adaptive and optimal control - End effectors - Classification - Mechanical - Magnetic -Vacuum - Adhesive - Drive systems - Force analysis and Gripper design.

4. ROBOT PROGRAMMING 6

Methods - Languages -Computer control and Robot Software - VAL system and Language.

5. SENSORY DEVICES 12

Non optical and optical position sensors - Velocity and Acceleration - Range - Proximity - touch - Slip - Force - Torque - Machine vision - Image components - Representation - Hardware - Picture coding - Object recognition and categoristaion - Software consideration.

Total No of periods: 45

References:

1. *Fu K.S., Gonzalez R.C., and Lee C.S.G., " Robotics control, sensing, vision, and intelligence ", McGraw-Hill Book Co., 1987.*
2. *Klafter R.D., Chmielewski T.A. and Negin M., " Robot Engineering An Intergrated approach ", Prentice Hall of India, New Delhi, 1994.*
3. *Deb S.R., " Robotics Technology and Flexible Automation ", Tata McGraw-Hill Publishing Co., Ltd., 1994.*
4. *Craig J.J., " Introduction to Robotics Mechanics and Control ", Addison-Wesley, 1999.*
5. *Groover M.P., " Industrial robotics Technology, programming and applications ", McGraw-Hill Book Co., 1995.*

Web Reference:

1. *<http://www.robotics.com>*

1. MECHANISMS AND TYPES OF CORROSION 10

Principles of direct and Electro chemical corrosion, Hydrogen evolution and oxygen absorption mechanisms - Galvanic corrosion, Galvanic series - Specific types of corrosion such as, Uniform, pitting, Intergranular, Cavitation, Crevice, Fretting, Erosion and Stress corrosion - Factors influencing corrosion.

2. TESTING AND PREVENTION OF CORROSION 8

Corrosion testing techniques and procedures - Prevention of corrosion - Design against corrosion - Modification of corrosive environment - Inhibitors - Cathodic protection - Protective surface coatings.

3. CORROSION BEHAVIOUR OF MATERIALS 8

Corrosion of Steels, Stainless steels, Aluminium alloys, Copper alloys, Nickel and Titanium alloys - Corrosion of polymers, Ceramics and composite materials.

4. SURFACE ENGINEERING FOR WEAR AND CORROSION RESISTANCE 10

Diffusion coatings - Electro and Electroless plating - Hot dip coating - Hard facing - Metal spraying, Flame and Arc processes - Conversion coatings - Selection of coating for wear and corrosion resistance.

5. THIN LAYER ENGINEERING PROCESSES 9

Laser and Electron Beam hardening - Effect of process variables such as power and scan speed - Physical vapour deposition, Thermal evaporation, Arc vapourisation, Sputtering, Ion plating - Chemical vapour deposition - Coating of tools, TiC, TiN, Al₂O₃ and Diamond coating properties and applications of thin coatings.

Total No of periods: 45

References:

1. Fontana, G., " Corrosion Engineering ", McGraw-Hill, 1985.
2. Schweitzer P.A., " Corrosion Engineering Hand Book ", 3rd Edition, Marcel Decker, 1996.
3. Winston Revie, R, Uhlig's " corrosion, Hand Book ", 2nd Edition, JohnWiley, 2000.
4. Kammeth G. Budinski, " Surface Engineering for Wear resistance ", Prentice Hall, 1988.
5. Metals Handbook, Vol.5, " Surface Engineering ", ASM International, 1996.

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1. www.hw.ac.uk/mecwww/research/an/coserg-2.htm

PE041 Computer Applications in Manufacturing

3 0 0 3

1. PRE-PLANNING 5

Introduction - Computer - Hardware and software -Types and systems organisation - Applications in Sales forecasting, Marketing - Cost and profit analysis.

2. PRODUCT CONCEPTS 10

Product Design - Computer Application - Optimisation of product features and parameters - FEM and FEA Design for Quality and cost - Robust design through Computer programming.

3. PROCESS DESIGN AND ESTIMATION 10

Process Design - Process planning and control - Tool design and selection -Related softwares - Computer aided MRP - Scheduling and control. Computer Aided MRP - Scheduling and Control.

4. COMPUTER AIDED TECHNIQUES 10

CNC Machining - Machine tools machines - Micro machines - Precision Manufacturing systems - Part programming - CAD/CAM Interfacing. Computer Aided Inspection - CMM, AFM, Talysurf instruments - Quality control.

5. COMMUNICATION AND DEVELOPMENTS 10

Net working system - Computer Aided communication - Feed back - Research and Development - Recent Developments - Design for productivity - Group technology - Cost estimation.

Total No of periods: 45

References:

1. Grover, " CAD/CAM ", Prentice Hall.
2. Radhakrishnan, R., CIM, " New Central Book agency ".
3. Grahens T Smith, " CNC Machining Technology ", Springer, Verlag, 1993.I.
4. Pressman, R.S and Willaim, J.E., " Numerical contol and CAD ", John Wiley and Sons, Inc., NewYork, 1997.
5. Yoram Koran, " CNC Machines ".
6. Barry L.Jones, " Introduction to CNC ", John Wiley and Sons Inc., NewYork, 1988.

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1. www.intelitek.com/tek08computer.htm
2. www.isc.edu/mnftc/mnftc125.htm

1. MECHANICS OF MACHINING 9

Stereometry of cutting tools - Orthogonal and oblique cutting - Derivation of equation of forces - Shear plane angle - Merchants theory.

2. THERMAL ASPECTS OF MACHINING 9

Heat development in machining - Effects of various parameters -Measurement methods to determine Chip tool interface temperatures - Action of cutting fluids - Failure of cutting tools - Plastic failure - Brittle fracture - Wear machinability.

3. MACHINE TOOL VIBRATION 9

Types of machine tool vibration - self excited vibration - Avoidance of chatter and vibration - Stick slip motion - NC system stability.

4. ECONOMICS OF MACHINING PROCESSES 9

Costs associated with machining operations - Optimum cutting speed for minimum cost in turning - Optimum cutting speed for maximum profile rate -Effect of feed on cutting speed for minimum cost - Restriction on optimum cutting conditions - Effect of stochastic variability of work and tool properties - Optimization of multi-stage batch machining.

5. SPECIAL MACHINING 9

High pressure cutting - Deep hole reaming - Deep hole drilling - Gun drills -Gun boring - Trepanning - Honing - Lapping - Super finishing - Burnishing -Broaching - Surface broaching.

Total No of periods: 45

References:

1. Juneja, B.L. and Sekhon, G.S., " *Fundamentals of Metal cutting and Machine tools* ", New Age International (P) Ltd., NewDelhi, 2000.
2. Bhattacharya, " *Metal cutting Theory and Practice* ", Central Book Publishers, Calcutta, 1984.
3. Boothroyd, G., " *Fundamentals of Metal Machining and Machine Tools* ", McGraw-Hill Co., 1975.
4. Armarego E.J.A. and Brown R.H., " *The Machining of Metals* ", Prentice Hall of India, 1982.

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1. www.men10t00.com/engwide

1. INTRODUCTION	5
Chemistry and Classification of Polymers - Properties of Thermo Plastics - Properties of Thermosetting Plastics - Applications - Merits and Disadvantages.	
2. PROCESSING OF PLASTICS	12
Extrusion - Injection Moulding - Blow Moulding - Compression and Transfer Moulding - Casting - Thermo Forming.	
3. MACHINING AND JOINING OF PLASTICS	5
General Machining properties of Plastics - Machining Parameters and Their effect - Joining of Plastics - Mechanical Fastners - Thermal bonding - Press Fitting.	
4. INTRODUCTION TO COMPOSITE MATERIALS	5
Fibres - Glass, Boron, Carbon, Organic, Ceramic and Metallic Fibers - Matrix Materials - Polymers, Metals and Ceramics.	
5. PROCESSING OF POLYMER MATRIX COMPOSITES	9
Open Mould Processes, Bag Moulding, Compression Moulding with BMC and SMC - Filament winding - Pultrusion - Centrifugal Casting - Injection Moulding - Application of PMC's.	
6. PROCESSING OF METAL MATRIX COMPOSITES	9
Solid State Fabrication Techniques - Diffusion Bonding - Powder Metallurgy Techniques - Plasma Spray, Chemical and Physical Vapour Deposition of Matrix on Fibres - Liquid State Fabrication Methods - Infiltration - Squeeze Casting - Rheo Casting - Compocasting - Application of MMCS.	
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1. Harold Belofsky, *Plastics : " Product Design and Process Engineering*, Hanser Publishers, 1995.
2. Bera, E and Moet, A, " *High Performance Polymers "*, Hanser Publishers, 1991.
3. Hensen, F, " *Plastics Extrusion technology "*, Hanser Publishers, 1988.
4. Johannaber F, " *Injection Moulding Machines "*, Hanser Publishers, 1983.
5. Rauwendaal, C, " *Polymer extrusion "*, Hanser Publishers, 1990.
6. Rosatao, D.V., " *Blow Moulding Handbook*, Hanser Publisher, 1989.
7. Seamour,E.B., " *Modern Plastics Moulding "*, John Wiley.
8. John Dalmonte, " *Plastics Moulding "*, John Wiley.
9. Akira Kobyashi, " *Machining of Plastics "*, Mc-Graw Hill.
10. Krishan K.Chawla, " *Composite Materials science and Engineering "*, springer-Verlag, 1987.
11. Agarwal. D. and Broutman L.J., " *Analysis and Performance of Fiber Composites "*, Wiley, 1990.
12. Mallick, P.K. and Newman, S. " *Composite Materials Technology "*, Hanser Publishers, 1990.

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PE044 Total Quality System and Engineering

3 0 0 3

1. INTRODUCTION 9

Principles of Quality Management - Pioneers of TQM - Quality costs - Quality system Customer Orientation - Benchmarking - Re-engineering - Concurrent Engineering.

2. PRACTICES OF TQM 9

Leadership - Organisational Structure - Team Building - Information Systems and Documentation - Quality Auditing - ISO 9000 - QS 9000.

3. TECHNIQUES OF TQM 9

Single Vendor Concept - J.I.T. - Quality Function deployment - Quality Circles - KAIZEN - SGA - POKA - YOKE - Taguchi Methods.

4. STATISTICAL QUALITY CONTROL 9

Methods and Philosophy of Statistical Process Control - Control Charts for Variables and Attributes - Cumulative sum and Exponentially weighted moving average control charts - Others SPC Techniques - Process Capability Analysis - Six sigma accuracy.

5. ACCEPTANCE SAMPLING 9

Acceptance Sampling Problem - Single Sampling Plans for attributes - double, multiple and sequential sampling, Military standards - The Dodge - Roming sampling plans.

Total No of periods: 45

References:

1. *Mohamed Zairi, " Total Quality Management for Engineers ", Woodhead Publishing Limited 1991.*
2. *Harvid Noori and Russel, " Production and Operations mangament - Total Quality and Responsiveness ", McGraw-Hill Inc, 1995.*
3. *Suresh Dalela and Saurabh, ISO 9000 " A Manual for Total Quality Management ", S.Chand and Company Ltd., 1997.*
4. *John Bank, " The Essence of Total Quality Management ", Prentice Hall of India Pvt.Ltd., 1995.*
5. *Douglus C. Montgomery, " Introduction to Statistical Quality Control ", 2nd Edition, John Wiley and Sons, 1991.*
6. *Grant E.L and Leavensworth, " Statistical Quality Control ", McGraw-Hill, 1984.*

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2. www.mcb.co.uk/tam.htm

PE044 Total Quality System and Engineering

3 0 0 3

1. INTRODUCTION 9

Principles of Quality Management - Pioneers of TQM - Quality costs - Quality system Customer Orientation - Benchmarking - Re-engineering - Concurrent Engineering.

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Total No of periods: 45

1. METAL CUTTING AND TOOL MATERIALS 9

Orthogonal and oblique cutting - Types of tool wear, Abrasion, Diffusion, Oxidation, Fatigue and Adhesive wear - Prediction of tool life - Monitoring of tool wear, Cutting forces and vibration - Tool materials, Cemented carbide, Coated carbide, Cermet, Ceramic, CBN and PCD - Selection of machine parameters and Tools.

2. SPECIAL MACHINING 9

Deep hole drilling - Gun drills - Gun boring - Trepanning - Honing - Lapping - Super finishing - Burnishing - Broaching - High speed machining.

3. UNCONVENTIONAL MACHINING 9

Principles, processes, Various influencing parameters and Applications of - Ultrasonic machining, Electro Discharge Machining, Electro Chemical Machining, Electron and Laser Beam Machining, Plasma Arc Machining and Water Jet Machining.

4. RAPID PROTOTYPING 9

Stereolithography - Laminated object manufacturing - selective laser sintering - solid freeform - Vacuum casting - Resin injection - Applications of RPT - Surface roughness terms - Influence of machining parameters on surface roughness - Micro finishing process.

5. ARTIFICIAL INTELLIGENCE AND EXPERT SYSTEMS 9

Introduction - Pattern recognition - Control strategies - Heuristic search, Forward and Backward reasoning - Search algorithms - Game playing - Knowledge representation - structural representation of knowledge - Expert systems in manufacturing.

Total No of periods: 45

References:

1. *Armarego E.J.A. and Brown R.H., " The machining of metals ", Prentice Hall , 1982.*
2. *Battacharya," Theory of metal cutting ", NCB Agency, 1984.*
3. *HMT Manual, " Non-traditional machining methods ", 1975.*
4. *Rich E. and Knight K., " Artificial Intelligence ", McGraw Hill Inc, 1991.*
5. *Pham D.T., " Expert Systems in Engineering ", IFS Publishers, Springer-Verlag, 1988.*
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