NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI - 620 015

M.Tech. DEGREE

in

(MANUFACTURING TECHNOLOGY)

SYLLABUS

FOR

CREDIT BASED CURRICULUM

OPERATIVE FOR STUDENTS OF 2013 -2014 ADMISSION

4 SEMESTER PROGRAMME

CODE : PR

DEPARTMENT OF PRODUCTION ENGINEERING

JUNE 2013

NATIONAL INSTITUTE OF TECHNOLOGY: TIRUCHIRAPPALLI - 620 015
DEPARTMENT OF PRODUCTION ENGINEERING
M. Tech. MANUFACTURING TECHNOLOGY
Proposed CURRICULUM Operative for M.Tech (2013-2014)

Curriculum Structure:

The total minimum credits required for completing the programme is 66

CODE	Semester – 1	L	T	P	C	CODE	Semester – 2	L	T	P	C
MA 609	Computational Methods in Engineering	2	1	0	3	PR 602	Precision Machining and Metrology	3	0	0	3
PR 601	Tooling for Manufacturing	3	1	0	4	PR 604	Mechanics of Metal Forming	2	1	0	3
PR 603	Casting and Welding Technology	3	0	0	3	PR 606	Flexible Manufacturing Systems	3	0	0	3
PR 605	Manufacturing Management	3	0	0	3	PR 608	Modeling of Manufacturing Processes	3	0	0	3
---------	Elective I	3	0	0	3	---------	Elective III	3	0	0	3
---------	Elective II	3	0	0	3	---------	Elective-IV	3	0	0	3
PR 633	CNC and Micromachining Lab	0	0	3	2	PR 634	Manufacturing Process Modeling and Rapid Manufacturing Lab	0	0	3	2
PR 635	Advanced Production Processes Lab	0	0	3	2	PR 636	Mechatronics and Computer Integrated Manufacturing Lab	0	0	3	2
		17	2	6	23			17	1	6	22

CODE	Semester – 3	L	T	P	C	CODE	Semester – 4	L	T	P	C
PR 647	Project Work - Phase-I	0	0	24	9	PR 648	Project Work - Phase-II	0	0	24	12
					9						12

List of Electives:

CODE	COURSE OF STUDY (Materials and Process Stream)	L	T	P	C	CODE	COURSE OF STUDY (Product and System stream)	L	T	P	C
PR 611	Industrial Welding Applications	3	0	0	3	PR 623	Computer Aided Design and Manufacturing	3	0	0	3
PR 612	Machine Tool Technology	3	0	0	3	PR 624	CNC Technology and Production Automation	3	0	0	3
PR 613	Manufacturing of Non-metallic Products	3	0	0	3	PR 625	Rapid Manufacturing	3	0	0	3
PR 614	Materials Technology	3	0	0	3	PR 626	Robotics	3	0	0	3
PR 615	Mechanical Behaviour of Materials	3	0	0	3	PR 627	Robust Design	3	0	0	3
PR 616	Mechanics of Composite Materials	3	0	0	3	PR 628	Terotechnology	3	0	0	3
PR 617	Metal Cutting Technology	3	0	0	3	PR 629	Tolerance Technology	3	0	0	3
PR 618	Theory of Plasticity	3	0	0	3	PR 630	Mechatronics and Automation	3	0	0	3
PR 619	Tribology	3	0	0	3	PR 631	Design for Manufacture	3	0	0	3
PR 620	Lasers in Manufacturing	3	0	0	3		**Common Electives with M.Tech (IE&M)**				
PR 621	Heat Treatment	3	0	0	3	PR 654	Modelling and Simulation	3	0	0	3
PR 622	Non-Destructive Testing	3	0	0	3	PR 658	Project Management	3	0	0	3
						PR 661	Intelligent Manufacturing Systems	3	0	0	3
						PR 670	Sustainable Manufacturing	3	0	0	3
						PR 677	Product and Life Cycle Assesment	3	0	0	3

MA 609 COMPUTATIONAL METHODS IN ENGINEERING

Algebraic equations: Formulation and solution of linear algebraic equations, Gauss elimination, LU decomposition, iteration methods (Gauss- Siedel), convergence of iteration methods, Eigen values and Eigen vectors.

Interpolation methods: Newton's divided difference, interpolation polynomials, Lagrange interpolation polynomials, Differentiation and Integration: High accuracy differentiation formulae, extrapolation, derivatives of unequally spaced data, Gauss quadrature and integration

Differential equations: Initial and boundary value problems, Eigen value problems, solutions to elliptical and parabolic equations, partial differential equations

Statistical methods: Statistical representation of data, modeling and analysis of data, tests of hypotheses, Introduction to regression analysis

Introduction to optimization methods: Local and global minima, Line searches, Steepest descent method, Conjugate gradient method, Quasi Newton method, Penalty function, Introduction to heuristic techniques.

REFERENCES

1. *Schilling R.J and Harris S L, "Applied Numerical Methods for Engineering using MatLab and C", Brooks/Cole Publishing Co., 2000.*
2. *Chapra S C and Canale R P, "Numerical Methods for Engineers", McGraw Hill, 1989.*
3. *Hines, W.W and Montogomery, "Probability and Statistics in Engineering and Management Studies", John Willey, 1990.*
4. *Santhosh K.Gupta, "Numerical Methods for Engineers", New age international publishers, 2005.*
5. *Deb Kalyanmoy, " Optimization for Engineering Design: Algorithms and Examples" Prentice-Hall of India Pvt.Ltd, 10th edition, 2009*

PR 601 TOOLING FOR MANUFACTURING

Introduction to manufacturing processes – objectives, organization and role of tool engineering – role of materials in tooling.

Tooling for material removal process like traditional machining processes, nontraditional machining processes automats and NC and CNC machines.

Tooling for forming processes.

Tooling for casting and metal joining processes – molding and pattern design mechanization of foundries Design of welding fixtures – tooling for mechanical joining processes.

Tooling for inspection and gauging – design and manufacturing of gauges – CMM – CAD in tool design.

REFERENCES

1. *Hoffman E.G, "Fundamentals of tool design", SME, 1984.*
2. *Kalpakjian S., "Manufacturing Engineering and Technology", Addision Wesley, 1995.*
3. *HMT "Production Technology", Tata McGraw Hll, 1991.*

PR 603 CASTING AND WELDING TECHNOLOGY

Core making processes - design for moulding and casting - different moulding and casting processes.

Melting and quality control of various steels and non-ferrous alloys - casting defects - Inspection and testing of casting

Welding processes classification, arc welding processes- solid phase welding processes, different types weld joints, welding positions. Brazing, soldering and adhesive bonding, process principles & applications..Weld Surfacing & cladding: Thermal cutting, oxy-acetylene cutting, Plasma cutting, laser cutting, process principles, applications, advantages & limitations.

Basics of welding metallurgy, thermal cycle,weld and their characteristics, Hot and cold cracking, measures to avoid hot, cold cracking in welds.

Inspection & testing of weld joints - Special welding processes - Friction Stir welding, Laser-hybrid welding. Safety aspects in welding.

REFERENCES

1. *P .L.Jain "Principles of foundry Technology" Tata Me Graw Hill Publishers.*
2. *Dr.R.S.Parmer "Welding processes and Technology" Khanna Publishers.*
3. *H.S.Bawa "Manufacturing Technology-I" Tata Me Graw Hill Publishers New Delhi, 2007.*
4. *S.V.Nadkami, Modem Arc Welding Technology, Oxford & IBH Publishing Co. Pvt. Ltd.*

PR 605 MANUFACTURING MANAGEMENT

Strategy Planning- Strategic, Tactical and Operational decisions.

Discrete and continuous facility location models location-allocation problems formulations,

Tactical planning- aggregate production planning models, Inventory management, Scheduling Flow shop Assembly Line Balancing Project Scheduling

Material Requirement Planning (MRP),Lot sizing in MRP, MPS, ERP,

SCM, concept of quality management.

REFERENCES

1. H.G. Menon,, "TQM in New Product Manufacturing", McGraw Hill, 1992.
2. Hax and Candea., "Production and Inventory Management", Prentice Hall, 1984.
3. Buffa., "Modern Production Management", John Welley, 1983.
4. Douglus C.Montgomery, Introduction to statistical quality control, 2nd Edition , Jhon Wiley & sons, 1991
5. Sunil Chopra, Peter Meindl, Supply Chain Management: Strategy, Planning and Operations-, Prentice Hall India, 3rd ed. (2007)

PR 633 CNC AND MICRO-MACHINING LAB

List of Experiments:

1. Exercise on Step turning operation on LEADWELL machine.
2. Exercise on External threading operation on LEADWELL and STC 15 machines.
3. Exercise on Profile milling operation on VMC machine.
4. Exercise on Rectangular pocketing and drilling operations on EMCO milling machine.
5. Exercise on Mirroring operation on MTAB milling machine.
6. Exercise on Measurement of surface roughness on machined component.
7. Exercise on computer aided part-programming for machining operations.
8. Exercise on Micro-turning operation on DT-110 Multi-process micro-machining center.
9. Exercise on Micro-milling operation on DT-110 Multi-process micro-machining center.
10. Exercise on Micro-drilling operation on DT-110 Multi-process micro-machining center.

PR 635 ADVANCED PRODUCTION PROCESSES LAB

List of Experiments:

1. Exercise on Measurement of Specific cutting energy in turning Process.
2. Exercise on Temperature measurement in drilling.
3. Exercise on Electrical Discharge Machining.
4. Exercise on Electrochemical Machining.
5. Exercise on Resistant welding & Fusion Welding of polymeric composites.
6. Exercise on Production of polymer components by Injection moulding.
7. Exercise on Electrical Discharge Alloying and Characterization
8. Exercise on Stir casting of Aluminum based composites.
9. Exercise on Weld bead performance on GMAW
10. Exercise on Measurement of temperature distribution on GTAW process using thermocouple.
11. Exercise on Water Hammer Forming
12. Exercise on Abrasive Machining

PR 602 PRECISION MACHINING AND METROLOGY

Micromachining-classification-mechanical advanced micromachining processes-advanced nano finishing processes- Micro Electro Mechanical Systems (MEMS) - Nano Electro Mechanical Systems (NEMS)
Lithography-diamond turning- micro drilling - micro milling - Electrical Discharge Micro-Machining (EDMM)
Wire Electrical Discharge Micro-Machining (EDMM)-Electrical Discharge Grinding (EDG)-Electro Chemical Micro-Machining (ECMM) – Laser Micro-Machining (LMM)
Nano finishing- magnetorheological finishing process-micro/nano finishing with flexible flow of abrasives- Electrolytic In-process Dressing (ELID) Grinding-Emerging trends in manufacturing.
Metrology of micro machined components-profilometers- optical microscopy- confocal laser scanning microscopy- Scanning Electron Microscope (SEM)-Atomic Force Microscope (AFM).

REFERENCES

1. *M.J. Madou, "Fundamentals of Micro Fabrication", CRC Press, 2002*
2. *V.K.Jain, "Introduction to Micromachining", Narosa Publishing House, 2010*
3. *Mark J. Jackson, "Micro Fabrication and Nano machining", Taylor and Francis, 2006*
4. *Serope Kalpakjain, "Manufacturing Engg. and Technology", Pearson Education, 2005*
5. *Yi Qin, "Micro-Manufacturing Engineering and Technology", Elsevier Publication,2010*

PR 604 MECHANICS OF METAL FORMING

Basics of metal forming - Mohr's circle - isotropic elasticity - yield theories - plastic stress-strain relationship - plastic work - the principle of normality - incremental plastic strain.
Constitutive relationships - mechanical properties - work hardening - compression test, bulge test, plane strain compression test - plastic instability in tension tests.

Strain rate - super plasticity - slab analysis for sheet drawing - Extrusion and forging - upper bound solution for Extrusion - Indentation and plane strain forging.

Slip line field theory and its solution - Formability and its testing.
Sheet Metal forming - Bending theory, Cold Rolling theory - Hill's anisotropic plasticity theory - Hill's general yield theory, CAD/CAM applications in Extrusion, Forging and sheet metal Forming - Localized necking in biaxial stretching.

REFERENCES

1. *Hosford W.F and Caddell, R.M,, "Metal Forming Mechanics and Metallurgy", Prentice Hall, 1983.*
2. *Narayanasamy R., "Theory of Plasticity", Ahuja Publications, 2000.*
3. *Scrope Kalpakjian,, "Manufacturing processes for Engineering Materials", Addision Wesley, 1997.*

PR 606 FLEXIBLE MANUFACTURING SYSTEMS

Introduction to FMS - concepts, advantages, components and examples of FMS, Distributed Numerical Control (DNC) - Communication between DNC computer and MCU.

Distributed data processing in FMS - Computer network protocols - Interfacing of CAD and CAM - Part programming in FMS tool data base - Clamping devices and fixtures data base, tool management system part alignment and work mounting errors, surface description method for automated design and robotized assembly.

Material Handling systems - ASRS - AGVs – features of industrial robots - robot cell design and control.

Inspection - CMM - incycle gauging - Sensors for robots.

Interfacing of computer - machine tool controllers and handling systems: communications standards - programmable Logic Controllers(PLC's) – Interfacing - Computer aided Project planning - Inventory control.

REFERENCES

1) Mikell P Groover, "Automation Production systems, Computer Integrated Manufacturing", Prentice Hall,1987.

2) Paul Ranky., "The design and operation of FMS", IFS publication.,, 1983.

3) Viswanathan, N & Nahari, Y, "Performance modeling of automated manufacturing systems", Prentice Hall,1992.

PR 608 MODELING OF MANUFACTURING PROCESSES

Review of manufacturing processes - need of numerical simulation of manufacturing processes
Basics of Finite Element Method (FEM), material and geometrical non-linearity – element equations for structural problems
Stress- strain relations - Application of FEM to non-linear structural problems, steady state and transient thermal problems - Fluid flow problems
Lagrangean and Eulerian formulations for the modeling of forming and machining processes – coupled thermoelasticity formulation for the modeling of welding process
Methods for modeling of manufacturing processes (welding, casting, forming and machining) - approach to modeling of machining of composites – analysis of causes of errors in solution

REFERENCES

1. *S.S.Rao, "The Finite Element Method in Engineering", Third Edition, Butterworth HeinemannPublishers, 1998.*
2. *Chandrupatla, Belegundu, "Introduction to Finite Elements in Engineering", 3rd Edition, Prentice Hall College Div, 2010*
3. *Edward R Champion Jr,, "Finite Element Analysis in Manufacturing Engineering", Mc Graw Hill, 1992.*
4. *Prakash M. Dixit, Uday S. Dixit "Modeling of Metal Forming and Machining Processes", 1st Edition, 2008, Springer Verlog.*
5. *Lars-Erik Lindgren, "Computational welding mechanics" , 1st Edition, 2007, CRC Press,*

PR 634 MANUFACTURING PROCESS MODELING AND RAPID MANUFACTURING LAB

List of Experiments:

1. Analysis of stress strain distribution in a plate with center hole using Matlab coding
2. Transient heat transfer analysis of a rectangular slab using a FEA package
3. Modeling & simulation of hot forging operation using a FEA package
4. Modeling & simulation of orthogonal machining using a FEA package
5. Modeling & simulation of cold rolling operation using a FEA package
6. Modeling & simulation of milling operation using a FEA package
7. Exercise on selection of Rapid Prototyping Technology
8. Case analysis on various phases of Rapid Product Development
9. Exercise on development of prototypes using 3D Printer
10. Life Cycle Assessment using GaBi package

PR 636 MECHATRONICS AND COMPUTER INTEGRATED MANUFACTURING LAB

List of Experiments:

1. Simulation of hydraulic circuits in a hydraulic trainer.
2. Simulation of single and double acting cylinder circuits using different directional control values
3. Simulation of Electro-pneumatic latch circuits
4. Simulation of Logic pneumatic circuits
5. Simulation of electro pneumatic sequencing circuits
6. Simulation of PLC based electro pneumatic sequencing circuits
7. Measurement of form tolerance (circularity, cylindricity and perpendicularity) using CMM
8. Robot programming for pick and place of jobs with vision system
9. Study and function of ASRS
10. Simulation of CIM environment

PR 611 INDUSTRIAL WELDING APPLICATIONS

Application of welding in heavy engineering: Boiler manufacture - boiler drum, water wall panels, headers, economizers. Heat exchangers.
Application of welding in oil & gas industries: orbital pipe welding, welding consumables, fabrication codes, inspection & testing, acceptance criteria.

Application of welding in Nuclear Power: Materials, processes, fabrication codes, inspection & testing, reasons for stringent quality control measures.

Application of welding in Automotive industries: Thin sheet welding, selection of materials and welding processes, inspection and testing procedure, acceptance criteria.

Application of welding in shipbuilding: Materials involved, welding processes, fabrication code, inspection & testing, acceptance criteria.

REFERENCES

1. *American Welding Society, 'Guide for Steel Hull Welding', 1992*
2. *Gooch T. S; 'Review of Overlay Welding Procedure for Light Water Nuclear Pressure Vessels', American Welding Society, 1991*
3. *Winter Mark H, 'Materials and Welding in Off-Shore Constructions', Elsevier, 1986*
4. *Welding Institute Canada, 'Welding for Challenging Environments', Pergamon Press, 1996.*
5. *Mishra, R.S and Mohoney, M W, Friction stir welding and processing, ASM 2007.*

PR 612 MACHINE TOOL TECHNOLOGY

Metal cutting machine tools and their specifications - machine beds and columns - relative merits of different types of beds and columns - design of beds and columns -force on cutting tool.
Types and design of slideways - wear adjustments.
Design of spindles and bearings – example for lathe, drilling machine and milling machine, choice of bearings.
Types of drives for machine tool – step and stepless – speed and feed mechanisms – kinematic diagrams.
Machine tool vibration – types - effect of undeformed chip thickness variations, rake and clearance angle variations - stability of cutting operation - regenerative chatter - testing of machine tools for alignment and accuracy - standard test charts.

REFERENCES

1. *Sen and Bhattacharya,, "Principles of Machine Tools", New Central Book Agencies, 1975.*
2. *Boothroyd,G., "Fundamentals of Metal Machining and Machine Tools", Mc Graw hill, 1985.*
3. *Acherkan,, "Machine Tool Design", Vol 2 & 3, MIR Pub, 1973.*

PR 613 MANUFACTURING OF NON-METALLIC PRODUCTS

Polymers - classification - Thermoplastics and thermosetting plastics - Thermoforming processes - compression and transfer molding - injection molding - extrusion - blow molding - calendaring - lamination and pultrusion.
Rubber - additives - applications. Stages in raw rubber and latex rubber technology - Processing of rubbers –Manufacturing techniques - tyres - belts - hoses - foot wears - cellular products - cables. Manufacture of latex based products
Glass - characteristics - application - glass making - Glass forming machines - hollow wares flat glasses, fiberglass, bulbs, bottles, heat absorbing glasses, amber glass and their manufacturing methods, general plant layouts for manufacture of different types of glasses.

Ceramics - classification - traditional ceramics - structural ceramics - fine ceramics - bio ceramics - ceramic super conductors. Ceramic processing techniques - hot pressing - hot isostatic pressing (HIP) - Sintering - injection molding - slip casting - tape casting - gel casting - extrusion. Composites - requirements of reinforcement and matrix - Manufacturing of composites - casting - solid state diffusion - cladding - HIP - liquid metal infiltration - liquid phase sintering - preparation of molding compounds and prepregs - hand layup method - autoclave method - filament winding method - compression molding - reaction injection molding - knitting - braiding.

REFERENCES

1. *J. A. Brydson, Newnes-Butterwarths, Plastic materials, London, 1989.*
2. *J. L. White, Rubber Processing Technology, Materials and Principles, Hanser Publishers, 1995.*
3. *E. B. Shand, Glass Engineering Handbook, McGraw-Hill, 2nd Edition, 1958.*
4. *M.W. Barsoum, Fundamentals of Ceramics, McGraw-Hill Co., Inc., 1997.*
5. *George Lubin, Handbook of Composites, Springer, 1st Edition, 1982.*

PR 614 MATERIALS TECHNOLOGY

Classification of materials – mechanical properties of metals.
Plastic instability – strain hardening / work hardening – strengthening mechanisms – cold working and recrystallization.

Plastic working of metals – formability of sheet metals – Forming Limit Diagram (FLD) –super plastic forming.
Workability of bulk metals – workability diagrams – necking and fracture of metals.

Machinability of carbon steels and nonferrous metals – machinability index.

REFERENCES

1. *Geller Y.A and Rakhshtadr "Science of Materials", MIR Pub, 198.6*
2. *Narayanasamy R., "Theory of Plasticity", Ahuja publications, 2000.*
3. *S.Kalpakjian, "Manufacturing Processes for Engineering Materials", Addision Wesley Pub Co, 1997.*

PR 615 MECHANICAL BEHAVIOUR OF MATERIALS

Introduction, Stress and strain relations, mechanical testing, Elements of plasticity, the flow curve, Strain hardening, Strain rate and temperature dependence of flow stress.

Plastic deformation, slip in crystals, dislocations, and dislocation motion. Twins, strengthening mechanisms, grain boundaries, solid solution strengthening and strain hardening.

Fracture, types of fracture, brittle fracture, Griffith theory of brittle fracture of material, ductile fracture, notch effects, and fracture mechanics.

Fatigue, the S-N curve, low cycle fatigue, structural features, surface effects, Creep, stress rupture test, structural changes, creep mechanisms and super plasticity

Embrittlement, residual stresses, mechanical behavior of Ceramics, glasses, polymeric materials, and composite materials.

REFERENCES

1. *Dieter, G. E., "Mechanical Metallurgy", 3rd Ed., McGraw Hill. 1988*
2. *Courtney, T.H., "Mechanical Behavior of Materials", 2nd Ed., McGraw Hill. 1990*
3. *Meyers, M.A. and Chawla, K.K., "Mechanical Behavior of Materials", Prentice Hall. 1999*
4. *R.W.K., "The Plastic Deformation of Metals", Edward Arnold.*

PR 616 MECHANICS OF COMPOSITE MATERIALS

Classification, Types, characteristics and selection of composites, prepegs, sandwich construction.

Micro and Macro mechanics of a lamina**:** four elastic moduli – Rule of mixture, ultimate strengths of unidirection lamina - Hooke's law - number of elastic constants - Two – dimensional relationship of compliance & stiffness matrix.

Macro Mechanical analysis of laminate - Kirchoff hypothesis – CLT, A,B,& D matrices - Engineering constants - Special cases of laminates, Failure criterion.

Manufacturing processes and Quality assurance of composites.

Metal matrix composites, Application developments - future potential of composites.

REFERENCES

1. *Mein Schwartz,, "Composite Materials Hand Book", Mc Graw Hill, 1984.*
2. *Autar K. Kaw, "Mechanics of Composite Materials", CRC Press, 1994.*
3. *Rober M Joness, "Mechanics of Composite Materials", Mc Graw HIll,1982.*

PR 617 METAL CUTTING TECHNOLOGY

Basic mechanism of chip formation – Orthogonal Vs Oblique cutting - Energy Consideration in machining - Modern theories in Mechanics of cutting.

Nomenclature of single point tool - multi point tools. Forces in turning, drilling and milling - measurement of cutting forces.

Thermodynamics of chip formation - Method of temperature measurement in machining - Hot machining - cutting fluids.

Essential requirements of tool materials - Conventional and accelerated tool life tests - Concepts of machinability - Economics of machining

Reasons for failure of cutting tools and forms of wear - chatter in machining - Finite element analysis of metal cutting process.

REFERENCES

1. *SHAW .M.C., " Metal cutting Principles ",Oxford clarendon Press,1984.*
2. *BHATTACHARYA. - " Metal Cutting Theory and Practice ", New central Book Agency(p) Ltd.,Calcutta1984.*
3. *VENKATESH .V.C. & CHANDRASEKHARAN.H. - " Experimental Techniques in Metal cutting ", Prentice Hall of India,1982*
4. *JUNEJA.B.L AND SEKHON.G.S- " Fundamentals of metal cutting and machine tools ", New Age International(p) Ltd., 1995*
5. *XING SHENG LI & LOW I.M., Editors Advanced Ceramic TRANSTECH PUBLICATIONS,1994.*
6. *KUPPUSWAMY.G.- " Pinciples of metal cutting ", Universities Press(India)Ltd., 1996*
7. *BOOTHROY.D.G. and KNIGHT. W.A " Fundamentals of Machining and Machine tools "-Marcel Dekker,New York, 1989.*

PR 618 THEORY OF PLASTICITY

Iinvariance in terms of the deviatoric stresses, representative stress - Engineering and natural strains, cubical dilation, finite strains co-efficients, tensors.
Yield criteria for ductile metal - Yield criteria for an anisotropic material. – Plastic stress-strain relations.
Application to problems, using upper bounds.
Crystallography.
Plane plastic strain and the theory of the slip line filed, two dimensional problems of steady and non steady motion, plastic anisotropy.

REFERENCES

1. *Narayanasamy R, "Theory of Engineering Plasticity", Ahuja Publications, 2000.*
2. *Johnson and Mellor, "Plasticity for Mechanical Engineers", Ban Nostrand, 1973.*
3. *R.Hill , "The Mathematic theory of Plasticity", Oxford Publication, 1982.*

PR 619 TRIBOLOGY

Industrial significance of tribology - Strength and deformation properties of solids - physio-chemical characteristics of solid surfaces - Analysis of surface roughness - measurement.

Friction - classification - Adhesion theory of friction - Elastic, plastic and visco - elastic effects in friction - rolling friction - friction of materials - alloys - ceramics - polymers - Interface temperature of sliding surfaces - measurement.

Wear - abrasive wear - mechanisms – Forms of wear - wear of non-metallic materials.

Lubrication - hydro dynamic lubrication - Reynolds equation - hydrostatic lubrication - bearing analysis - elastohydrodynamic lubrication - solid lubrication - boundary lubrication.

Micro/nano tribology - Measurement techniques - Nanomechanical Properties of Solid Surfaces and Thin Films.

REFERENCES

1. *I.M. Hutchings, "Tribology: Friction and Wear of Engineering Materials", Elsevier Limited, 1992.*
2. *G. W. Stachowiak, A. W. Batchelor, "Engineering Tribology", Elsevier Limited, 2005.*
3. *K.C. Ludema, "Friction, wear, lubrication: A text book in tribology", CRC Press, 1996.*
4. *Bharat Bhushan, "Principles and applications of tribology", John Wiley & Sons, 1999.*
5. *Bharat Bhushan, "Nanotribology and Nanomechanics: An Introduction", Springer, 2008.*

PR 620 LASERS IN MANUFACTURING

Fundamentals of laser - properties - spectrum and wavelength - types of laser - laser components - interaction of laser radiation with materials.
Laser surface treatment - laser transformation hardening - advantages - laser surface melting - laser alloying - laser cladding.
Laser welding - process arrangement - mechanisms - applications - heat flow theory - one dimensional heat flow - model for stationary and moving point source - simulation of laser welding.
Laser cutting - theoretical models of cutting - practical performance -applications - process variations - drilling - applications.
Fiber Laser and UV Laser based marking - micromachining solutions - laser shock loading - basics - applications - laser safety - danger - safety limits - eye and skin - class four safety arrangements - electric hazards - fume hazards.

REFERENCES:

1. William M. Steen, "Laser Material Processing", Springer Verlag, 2003.
2. M.Young, "Optics and Lasers", Springer, 1993.
3. K.Thyagarajan, Ajoy K.Ghatak, "Lasers, Theory and Applications", Plenum Press, 1981.
4. J.F. Reddy, "Industrial Applications of Lasers", Academic Press, New York, 1978.
5. S. S. Charschan, "Lasers in Industry", Wiley & Sons Inc., 1974.
6. Michael Bass, "Laser Materials Processing", Elsevier Science, 1983.

PR 621 HEAT TREATMENT

Iron - Carbon Equilibrium Diagram: Heat treatment effects on alloying elements. Typical Applications of Heat treatments in Manufacturing Industries.
Various heating media used for heat treatment, furnaces, Temperature and atmosphere control.
Heat Treatment Processes: Annealing – Normalising, TTT&CCT diagrams, Hardenability studies, Jominy end quench test, Grossman's experiments - Tempering, Austempering and Martempering. Thermomechanical treatments.
Surface Modification Techniques: Induction hardening, flame hardening, electron beam hardening and Laser beam hardening. Carburising, nitriding, carbonitriding, CVD and PVD processes, Ion implantation.
Heat Treatment Of Non-Ferrous Metals And Specific Alloy steels: Heat treatment of gray irons, white irons (malleabilising) and S.G.irons. Austempering of S.G.Iron.
Defects: Defects in heat treated parts, causes and remedy Design for heat treatment.

REFERENCES :

1. Rajan and Sharma "Heat Treatment Principles and Techniques" – Prentice Hall of India (P) Ltd, New Delhi, 2004.
2. Prabhudev, K H., "Handbook of Heat Treatment of Steels", Tata - McGraw Hill Publishing Co., New Delhi, 2000.
3. Vijendra Singh,"Heat Treatment of Metals", Standard Publishers Distributors, Delhi, First edition 1998.
4. American Society for Metals, "Metals Handbook Vol.4", ASM Metals Parks, Ohio, USA, 2001.
5. Karl-Erik Thelning, "Steel and its Heat Treatment", Butterworths London, second edition 1984.
6. Novikov I, "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978.

PR622 NON DESTRUCTIVE TESTING

Visual Inspection **:** Fundamentals of Visual Inspection - metallic materials, raw materials and welds - Inspection objectives, inspection checkpoints, sampling plan, inspection pattern etc. classification of indictions for acceptance criteria - Codes, Standards and Specifications (ASME,ASTM,AWS etc.)-Capabilities, Limitation and Applications

Liquid Penetrant Testing: Principles - types and properties of liquid penetrants - developers - advantages and limitations of various methods - Control and measurement of penetrant process variables - Limitation and Applications

Magnetic Particle Testing: Theory of magnetism - ferromagnetic, Paramagnetic materials - advantages - Circular magnetisation techniques, Limitation and Applications

Ultrasonic Inspection Methods, Equipment/Materials: Principle of pulse echo method, through transmission method, resonance method - Advantages, limitations - Focussing Techniques (SAFT), Time of Flight Diffraction (TOFD), Signal Analysis. Capabilities, Limitation and Applications

Characterization: X-ray Diffraction(XRD) - SEM, Photoluminescence(PL) – Raman Spectroscopy, UV-Vis-IR Spectrophotometer – AFM.

REFERENCES

1. American Metals Society, "Non-Destructive Examination and Quality Contro!", Metals Hand Book, Vol. I 7, 9th Ed, Metals Park, OH, 1989.
2. Krautkramer, Josef and Hebert Krautkramer, "Ultrasonic Testing of Materials", 3rd Ed, Newyork, Springer- verlag, 1983.
3. A. Goswami, "Thin film fundamentals", New age international (P) Ltd. Publishers, New Delhi, 1996.
4. Birchan, D, "Non Destructive Testing", Oxford University Press, 1977.

PR 623 COMPUTER AIDED DESIGN AND MANUFACTURING

Basic concepts of CAD - CAD workstation - principles of computer graphics - graphics programming - mechanical drafting package.

Advanced modeling techniques - surface modeling - solid modeling, rendering methods. Graphics and data exchange standards, CAD/CAM data base development and data base management systems.

Principles of optimum design - CAD optimization techniques, design for manufacture and assembly, principles of computer aided engineering, application of CAD, rapid prototyping, concurrent engineering.

Computer aided manufacturing, programming and interface hardware – computer aided process monitoring - adaptive control, on-line search strategies, computer-aided process planning.

Production systems at the operation level - computer generated time standards - machinability data systems - cutting conditions optimization - production planning - capacity planning - shop floor control - computer integrated manufacturing systems, application.

REFERENCES

1. *Radhakrishnan P & Kothandaraman C.P, "Computer Graphics and Design", Dhanpat Rai & Sons, 1990.*
2. *Groover M P, "Automation, Production System and Computer Aided Manufacture", Prentice Hall, 1984.*
3. *William M Newman & Robert Sproul,, "Principle of Interactice Computer Graphics", Mc Graw Hill, 1984.*

PR 624 CNC TECHNOLOGY AND PRODUCTION AUTOMATION

Numerical Control (NC) - input media - design considerations of NC machine tools - functions of MCU- controls and system devices - CNC.

CNC programming- manual part programming – preparatory, miscellaneous functions – computed aided part programming - post processors - APT programming- programming for CNC turning center, machining center and CNC EDM.

Feedback devices– interpolators - tooling for CNC– point-to-point and contouring systems – DNC-Adaptive Control – ACO and ACC systems- graphical numerical control.

Automation – principles – strategies – levels of automation – automated manufacturing systems – devices, drives and control circuits in automation - semi-automats, automats and transfer lines.

Part families-classification and coding-cellular manufacturing- production flow analysis-automated material handling systems- automated storage systems-automatic data capture-automated assembly systems-industrial robots-applications-robot programming.

REFERENCES

1. *Yoram Koren, "Computer Control of Manufacturing Systems", McGraw Hill Book Co. New Delhi, 1986.*
2. *Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall of India, 2009.*
3. *Radhakrishnan P., "Computer Numerical Control Machines", New Book Agency, Calcutta, 1991*
4. *Kundra T. K., Rao P. N., and Tiwari N. K., "CNC and Computer Aided Manufacturing", Tata McGraw Hill, New Delhi, 1991.*
5. *Fitzpatric.M., "Machining and CNC Technology", McGraw Hill, 2004*

PR 625 RAPID MANUFACTURING

Introduction- Need for the compression in product development, History of RP systems, Survey of applications, Growth of RP industry, Classification of RP systems.

Principle, process parameters, process details and applications of various RP processes - Stereo lithography systems, Selective Laser Sintering, Fused Deposition Modeling, Laminated Object Manufacturing, Solid Ground Curing, Laser Engineered Net Shaping, 3D Printing.

Rapid Tooling: Indirect rapid tooling - silicone rubber tooling, aluminum filled epoxy tooling, spray metal tooling, Direct rapid tooling - direct AIM, copper polyamide, sand casting tooling, laminate tooling, soft tooling Vs hard tooling.

Rapid Manufacturing Process Optimization- Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation.

Concept Modelers and Software for RP: Various Concept Modelers - STL files, overview of solid view, magics, mimics, magics communicator, etc., internet based softwares, collaboration tools.

REFERENCES

1. *Pham D T and Dimov S S, "Rapid Manufacturing", Verlag, 2001.*
2. *Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME, 1996.*
3. *Terry Wohlers, "Wohlers Report 2001", Wohlers Associates, 2008.*
4. *Prasad H and Badrinarayanan, K S, "Rapid Prototyping and Tooling", SPI-Pageturners, Bangalore, India, 2013.*

PR 626 ROBOTICS

Fundamentals of robotics – wrists design - end effectors – actuators - modular robots.
Robot and its peripherals - sensors, machine vision - image processing & analysis - application of artificial intelligence, voice communication - robot control units - motion controls.
Robot kinematics - homogeneous transformations - forward & inverse kinematics - problems of dynamics - differential relationships - motion trajectories - dynamics of a robot control of single & multiple link robot - static force analysis.
Robot Programming - different languages - expert systems.
Robot applications in manufacturing - material transfer & machine loading/unloading - processing operations – inspection - automation - robot cell design – control – recent developments and special applications-Micro & Bio robotics.

REFERENCES

1. *Richard D Klafter, Thomas A Chmielewski & Michael Negin, "Robotic Engineering – An Integrated Approach", Prentice Hall, 1994.*
2. *Deb, S.R., "Robotic Technology and Flexible Automation", Tata Mc Graw Hill, 1994.*
3. *Fu & Gonzales,, "Industrial Robotics", Tata Mc Graw Hill, 1988.*

PR 627 ROBUST DESIGN

Introduction- Planning of experiments – Steps – Need - Terminology: Factors, levels, variables, experimental error, replication, Randomization, Blocking, Confounding.
Single Factor Experiments- ANOVA rationale - Sum of squares – Completely randomized design, Randomized block design, effect of coding, Comparison of treatment means – Newman Kuel's test, Duncan's Multiple Range test, Latin Square Design, Graeco-Latin Square Design, Balanced incomplete design.
Factorial Experiments-Main and interaction effects –Two and three Factor full factorial Designs, 2^k deigns with Two and Three factors-Unreplicated design- Yate's Algorithm
Special Experimental Designs: Blocking in factorial design, Confounding of 2^k design, nested design-Response Surface Methods.
Taguchi Techniques- Fundamentals of Taguchi methods, Quality Loss function, orthogonal array designs, application to Process and Parameter design, case studies.

REFERENCES

1. *Montgomery, D.C. "Design and Analysis of Experiments", John Wiley and Sons, 5th Edition, 2002.*
2. *Ross, P.J. "Taguchi Techniques for quality Engineering", Tata McGraw Hill, 2000.*
3. *Hicks,C.R. "Fundamental concepts in the Design of Experiments", Holt, Rinehort and Winston, 2000.*
4. *Bagchi, T.P. "Taguchi Methods explained", PHI, 2002.*

PR 628 TEROTECHNOLOGY

Basic Concepts of reliability –Reliability and Quality –Failures and Failure modes – Causes of failures and unreliability- Maintainability and Availability- Mathematical Expressions - Laplace Transform application in reliability.

Reliability analysis – Mathematical models – Designing for higher reliability– Reliability and Cost - Failure Data Analysis –MTTF in integral form- Numerical analysis.

Component reliability and Hazard Models – Nonlinear hazard model

Redundancy Techniques in System Design- Vibration analysis.

System reliability – Types, Fault Tree Analysis.

REFERENCES

1. *Srinath.L.S., "Reliability Engineering", Affiliated East West Press Pvt. Ltd.,1991.*
2. *Collacott,R.A. "Mechanical Fault Diagnosis & condition monitoring", Chapman and Hall London, 1977.*
3. *Balagurusamy.E., "Reliability Engineering", Tata McGraw- Hill Publishing Company Limited, New Delhi,1984.*
4. *Birolini.A., "Reliability Engineering: Theory and Practice", Springer-Verlag Publishers, Germany,2004, Fourth Edition.*

PR 629 TOLERANCE TECHNOLOGY

(Use of approved design data book is permitted in the examination)

Introduction to Geometric Dimensioning and Tolerancing ,Scope, Definitions, and General Dimensioning, General Tolerancing and Related Principles, Symbology , Datum Referencing, Tolerances of Location, Tolerances of Form, Profile, Orientation, and Runout

Properties of the surface , Principles for tolerancing , Principles for geometrical tolerancing.

Profile tolerancing, Tolerancing of cones, Positional tolerancing, Projected tolerance zone, Substitute elements, Maximum material requirement, Envelope requirement, Least material requirement

Tolerancing of flexible parts, Tolerance chains (accumulation of tolerances), Statistical tolerancing.

General geometrical tolerances, Tolerancing principles, Tolerancing of edges, ISO Geometrical Product Specifications (GPS).

REFERENCES

1. *Gene R. Cogorno "Geometric Dimensioning and Tolerancing for Mechanical Design", McGraw-Hill,2006*
2. *Georg Henzold "Geometrical Dimensioning and Tolerancing for Design, Manufacturing and Inspection-A Handbook for Geometrical Product Specification using ISO and ASME Standards", Elsevier, Second edition*
3. *Bryan R. Fischer "Mechanical Tolerance Stackup and Analysis" Advanced Dimensional Management, Sherwood, Oregon, U.S.A., Marcel Dekker,Inc.*
4. *ASME "Dimensioning and Tolerancing", Y14.5M-1994 [REVISION OF ANSI Y14.5M-1982 (RI98811)]*

PR 630 MECHATRONICS AND AUTOMATION

Need for Automation, Hydraulic & Pneumatic Comparison – ISO symbols for fluid power Elements

Hydraulic, pneumatic – Selection criteria. standard circuit symbols, circuit (flow) analysis.

Direction, flow and pressure control valves-electro hydraulic servo valves-Different types-characteristics and performance.

Typical industrial hydraulic circuits-Design methodology – Ladder diagram-cascade, method-truth table-Karnaugh map method-sequencing circuits-combinational and logic circuit. Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram.

Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits. Electronic drive circuits for various Motors.

REFERENCES

1. *Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988*
2. *Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967*
3. *Dudbey.A.Peace, Basic Fluid Power, Prentice Hall Inc, 1967*
4. *Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979*
5. *E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978.*
6. *W.Bolton, Mechatronics, Electronic control systems in Mechanical and ElectricaEngineering Pearson Education, 2003.*
7. *Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994.*

PR 631 DESIGN FOR MANUFACTURE

Engineering design – Kinds of design – Design process steps – Factors influencing design – Concurrent Engineering – Material selection process – Evaluation methods for material selection
Process capability analysis – Cumulative effect of tolerances – Centrality analysis – Compound assembly – Selective and Interchangeable assembly – Grouped Datum systems
Form Design of castings and weldments –Design for plastic parts - Design for machining – Design for economy – Design for clampability – Design for ease of assembly
Advances in DFMA- Design for robustness – Axiomatic design –DFA index – Poka Yoke – Lean principles – Six sigma concepts – Computer aided DFA using software.
Design for the Environment – Design Guidelines – Basic DFE methods –Life Cycle Assessment - Weighted sum assessment method – Techniques to reduce environmental impact – Design for disassembly – Design for recyclability – Design for remanufacture – Design for energy efficiency – Design to regulations and standards.

REFERENCES

1. *Matousek , R. "Engineering Design" Blackie and Son Limited, Glasgow, 1967.*
2. *Dieter, G.E. "Engineering Design: A Materials and processing Approach", McGraw Hill Co. Ltd, 2000.*
3. *Boothroyd, G. "Assembly, Automation and product design" CRC press, 2005.*
4. *Eggert, R.J. "Engineering Design" Pearson Education, Inc. New Jersey, 2005.*
5. *Peck, H. "Designing for Manufacture", Pitman Publications, London, 1983.*
6. *Kalandar Saheb, S.D and Prabhakar, O. "Engineering Design for Manufacture", ISPE 1999. Boothroyd, G., Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.*

COMMON ELECTIVES WITH M.Tech (IE&M)

PR 654 MODELING AND SIMULATION

Introduction to systems and modeling - discrete and continuous system - Monte Carlo Simulation. Random number generation Random variable generation – Testing -Analysis of simulation data - Input modeling – verification and validation of simulation models – output analysis for a single model. Simulation languages and packages-Case studies-Simulation based optimization

REFERENCES:

1. *Jerry Banks and John S.Carson, Barry L Nelson, David M.Nicol, P.Shahabudeen, Discrete event system simulation, Pearson Education, 2007.*
2. *Law A.M, Simulation Modelling and Analysis, Tata Mc Graw Hill,2008*
3. *Thomas J.Schriber, Simulation using GPSS, John Wiley, 1991.*
4. *Kelton, W. David, Simulation with Arena ,McGraw-Hill,2006*

PR 658 PROJECT MANAGEMENT

Capital investments: Importance and difficulties - Types of capital investments - Phases of capital budgeting - Levels of decision making - Facets of Project Analysis - Feasibility Study - Objectives of capital budgeting - Common weaknesses in capital budgeting - Project Life Cycle.

Technical analysis - Manufacturing process / technology - Materials and inputs - product mix - plant capacity - location and site - machinery and equipment – structures and civil works – project charts and layouts.
Capital allocation frame work - key criteria - Elementary investment options - Portfolio planning models - Strategic position and action evaluation (SPACE) - Financial estimates & Projections - Time value of money - Investment Criteria - Net present value - Benefit cost ratio - Internal rate of return - Payback period - Accounting rate of return.

Risk Analysis of single investments - Multiple projects and Constraints - Project dependence - Capital rationing - Project indivisibility. Mathematical Programming Approach - Linear programming model - Integer programming model - Goal programming model. Network techniques for project management - PERT, CPM.

Introduction to Software Project Management (SPM) - Software Metrics – Software quality – Risk management in SPM- Emerging issues.

REFERENCES

1. *Prasanna Chandra, "Project Management", Tata McGraw Hill, 2002.*
2. *Choudhury, S., "Project management", Tata McGraw Hill, 1988.*
3. *Walker Royce, Software project management, Addison Wesley, Pearson Education.*

PR 661 INTELLIGENT MANUFACTURING SYSTEMS

Basic concepts of Artificial intelligence and expert systems - System Components - System architecture and Data flow – System Operations

Knowledge based systems - knowledge representation – knowledge acquisition and optimization - Knowledge based approaches to design mechanical parts and mechansims and design for automated assembly

Knowledge based system for material selection – Intelligent process planning system.

Intelligent system for equipment selection - Intelligent system for project management & factory monitoring. Scheduling in manufacturing – scheduling the shop floor – Diagnosis & trouble shooting

The role of Artificial Intelligence in the factory of the future – Intelligent systems.

REFERENCES

1. *Andrew Kussiak,, "Intelligent Manufacturing Systems", Prentice Hall , 1990.*
2. *Simons, G.L, "Introducing Artificial Intelligence", NCC Pub, 1990.*
3. *Rich,E., "Artificial Intelligence", Mc Graw Hill, 1986.*

PR 670 SUSTAINABLE MANUFACTURING

Concepts of sustainability and sustainable development - Components of sustainability (Social, Economic, Environmental) - Linkages between technology and sustainability - Sustainable Manufacturing - Sustainable Product Development – Various Phases.

Tools and Techniques – Environmental Conscious Quality Function Deployment, Life cycle assessment, Design for Environment, R3 and R6 cycles, Design for Disassembly.

EIA Methods –CML, EI 95 and 99, ISO 14001 EMS and PAS 2050 standards, Environmental Impact parameters - Interactions between energy and technology and their implications for environment and sustainable development.

Design for recycling – Eco friendly product design methods – Methods to infuse sustainability in early product design phases – Multi-Criteria Decision Making in Sustainability.

Frameworks for measuring sustainability- Indicators of sustainability - Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment– Corporate Social Responsibility.

REFERENCES

1. *G. Atkinson, S. Dietz, E. Neumayer, ―Handbook of Sustainable Manufacturing‖. Edward Elgar Publishing Limited, 2007.*
2. *D. Rodick, Industrial Development for the 21st Century: Sustainable Development Perspectives, UN New York, 2007.*
3. *Rogers, P.P., Jalal, K.F. and Boyd, J.A., An Introduction to Sustainable Development, Earthscan, London, 2007.*
4. *P. Lawn, Sustainable Development Indicators in Ecological Economics, Edward Elgar Publishing Limited.*
5. *S. Asefa, The Economics of Sustainable Development, W.E. Upjohn Institute for Employment Research, 2005.*

PR677 PRODUCT AND LIFE CYCLE ASSESMENT

Product lifecycle management-concepts, benefits, value addition to customer. Lifecycle models-creation of projects and roles, users and project management, system administration. Product development process and functions

Data transfer. Variants of e-commerce. Multisystem information sharing.Workgroup collaboration. Development of standard classification for components and suppliers. Customization factors-creation of business objects, user interfaces, search facile ties as designed by the enterprise.

Quality function deployment-quality project approach and the problem solving process. Design creativity-innovations in design alternatives. Concurrent engineering, industrial design principles Product development versus design, types of design and redesign, examples of product development process, scoping product development – S-curve, new product development.

Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality. Tear down method, post teardown report, benchmarking and establishing engineering specifications, product portfolios.

Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis, concept selection, technical feasibility, ranking, measurement theory, DFMA, design for robustness. Types of prototypes, use of prototypes, rapid prototyping technique scale, dimensional analysis and similitude, physical model and experimentation.

REFERENCES

1. *John W Gosnay and Christine M Mears, "Business Intelligence with Cold Fusion", Prentice Hall India, New Delhi, 2000.*
2. *Alexis Leon, "Enterprise Resource Planning", Tata McGraw Hill, New Delhi, 2002.*
3. *David Bedworth, Mark Hederson and Phillip Wolfe, "Computer Integrated Design and Manufacturing" McGraw Hill Inc., New York, 1991.*
4. *Kevin Otto and Kristin Wood, "Product Design – Techniques in Reverse Engineering and New Product Development", Pearson Education, New Delhi, 2004.*
5. *John Stark "Product Lifecycle Management" Springer, 2011.*