M. Tech. Scheme (1st semester) (Production Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
ME-801	Advanced Manufacturing Processes	PC	3	3	0	0
ME-802	Machining Processes & Analysis	PC	3	3	0	0
ME-803	Quality Systems Engineering	PC	3	3	0	0
ME-804	Manufacturing Processes Design & Simulation	PC	3	3	0	0
ME-805	CNC Technology & Programming	PC	3	3	0	0
ME-806	CAD /CAE LAB	PC	2	0	0	4
ME-807	CAM. LAB	PC	1	0	0	2
	Total Credits		**18**			

M. Tech. Scheme (2nd semester) (Production Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
	Programe Elective-1	PE	3	3	0	0
	Programe Elective-2	PE	3	3	0	0
	Programe Elective-3	PE	3	3	0	0
	Programe Elective-4	PE	3	3	0	0
	Programe Elective-5	PE	3	3	0	0
	Programe Elective-6	PE	3	3	0	0
	Total credits		**18**			

List of Elective Courses

Course Code (ME-)	Course Title	Course Category	Credits	L	T	P
811	Computer Integrated Manufacturing		3	3	0	0
812	Automation in Manufacturing		3	3	0	0
813	Industrial Robotics and Expert Systems		3	3	0	0
814	Precision & Micro-machining		3	3	0	0
821	Advanced Metal Forming		3	3	0	0
822	Welding & Allied Processes		3	3	0	0
823	Advanced Casting Processes		3	3	0	0
831	MEMS & NEMS		3	3	0	0
832	Experimental Stress Analysis		3	3	0	0
833	Finite Element Method		3	3	0	0
841	Manufacture of Plastic Products		3	3	0	0
842	Rapid Prototyping & Tooling		3	3	0	0
843	Tool Engineering		3	3	0	0
851	Product Design & Development		3	3	0	0
861	Industrial Tribology		3	3	0	0
862	Reliability Centric Maintenance		3	3	0	0
863	Composite Materials & Processing		3	3	0	0

M. Tech. Scheme (3rd semester) (Production Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
ME-808	Seminar		4	0	0	4
ME-809	Dissertation		16	0	0	16
	Total credits		**20**			

M. Tech. Scheme (4th semester) (Production Engineering)

Subject Code	Course Title	Course Category	Credits	L	T	P
ME-810	Dissertation		16	0	0	20
	Total credits		**16**			

Detailed Syllabus (core courses)

ME-801 Modern Manufacturing Processes

L T P C
3 0 0 3

UNIT I

Advanced Machining Processes: Classification of Advanced Machining Process. MECHANICAL ENERGY BASED PROCESSES: AJM, WJM, AWJM and USM- Working Principles, Equipment, Process parameters, Applications. ELECTRICAL ENERGY BASED PROCESSES: EDM & WEDM - Working Principles, Equipment, Process parameters, Applications. CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES: CHM and ECM Working Principles, Equipment, Process parameters, Applications. THERMAL ENERGY BASED PROCESSES: LBM, PAM, EBM- Working Principles, Equipment, Process parameters, Applications.

UNIT II

Advanced Casting Processes: Metal mould casting, Continuous casting, Squeeze casting, Vacuum mould casting, Evaporative pattern casting, Ceramic shell casting.

UNIT III

Advanced Welding Processes: Electron beam welding (EBW), laser beam welding (LBW), ultrasonic welding (USW).

UNIT IV

Advanced Metal Forming Processes: Details of high energy rate forming (HERF) process, Electro-magnetic forming, explosive forming, Electro-hydraulic forming, Stretch forming, Contour roll forming

Text Books:

"Nontraditional Manufacturing Processes", G.F. Benedict, Marcel Dekker, Inc. New York.

"Advanced Machining Processes" Vijay.K. Jain, Allied Publishers Pvt. Ltd., New Delhi.

"Manufacturing Engineering & Technology", Kalpakjian. S., Pearson Education Asia.

Reference Books

"Materials and Processes in Manufacturing", E. P. DeGarmo, J. T Black, R. A. Kohser, Prentice Hall of India, New Delhi

"Manufacturing Science" A. Ghosh, and A. K. Mallik, Affiliated East-West Press Pvt. Ltd. New Delhi.

"Modern Machining Processes" Pandey P.C. and Shan H.S. Tata McGraw-Hill, New Delhi.

"Material and Processes in manufacturing" Paul De Garmo, J.T.Black, and Ronald.A.Kohser, Prentice Hall of India Pvt. Ltd., New Delhi.

Production Technology by HMT.

ME-802 Machining Processes & Analysis

L T P C
3 0 0 3

UNIT I

Introduction to Manufacturing and Machining: Identify the necessity of "manufacturing", Define with examples the concept of "manufacturing", List the main classifications of the manufacturing processes with examples , State the main purposes of "machining" , Define with examples the concept of "machining" , State with example the principles of "machining"**,** Define the concept of "machine tools".

UNIT II

Basic working principle, configuration, specification and classification of machine tools: (a) Describe the basic functional principles of machine tools (i) Illustrate the concept of Generatrix and Directrix (ii) Demonstrate Tool – work motions (iii) Give idea about machine tool drives (b) Show configuration of basic machine tools and state their uses (c) Give examples of machine tools - specification (d) Classify machine tools broadly

UNIT III

Tool Geometry: (a) learn geometry of single point turning tools (i) concept of rake and clearance angles (ii) systems of description of tool geometry (b) Study and show tool geometry (i) Machine Reference System (ASA) (ii) Tool Reference System

UNIT IV

Mechanics of Machining : (i) State the purposes of conversion of tool angles (ii) Identify the four different methods of conversion of tool angles (iii) Employ the graphical method for conversion of Rake angles, clearance angles, Cutting angles
From ASA to ORS and ORS to ASA systems (iv) Convert rake angle and clearance angle from ORS to NRS (v) Demonstrate tool angle's relationship in some critical conditions.

UNIT V

Mechanism of chip formation : (i) describe with illustration the mechanism of chip formation in machining • ductile materials and • brittle materials (ii) illustrate and assess geometrical characteristics of ductile chips : • chip reduction coefficient & cutting ratio • shear angle and cutting strain (iii) Identify and state the causes, characteristics and effects of built – up – edge (BUE) formation. (iv) Classify chips and identify the condition for different chip forms.

Orthogonal and oblique cutting: (i) define and distinguish, with illustrations, between orthogonal cutting and oblique cutting (ii) identify the causes of oblique cutting and chip flow deviation (iii) determine angle of chip flow deviation. (iv) illustrate and deduce effective rake angle (v) state the effects of oblique cutting.

Books

Modern machining process - PANDEY AND SHAH

Metal cutting theory and practice - A. Bhattacharyya

Manufacturing Science by Amitabha Ghosh and Mallik

ME-803 Quality Systems Engineering (Pre approved course)

L T P C

3 0 0 3

Fundamental of Quality, Contribution of quality gurus, quality cost. Statistical process control & process capability. Acceptance Sampling plans for attribute and variable. Taguchi quality loss function and concept of robust design. Concept of six sigma, FMEA, QFD, Poka Yoke. ISO 9000 series of standard, QS 9000, TQM, Quality circles. Benchmarking. Reliability.

Books recommended:

Grant, E.L.& Leavenworth R.S. Statistical Quality Control, McGraw Hill.

Juran J.M& Gryna F.M. Quality planning and analysis, McGraw Hill. Koru

Ishikawa, Guide to Quality Control, Asian Productivity Organization.

Amitava Mitra –Fundamentals of Quality Control & Improvement, Mcmillan Publishing Company.

ME-804 Manufacturing Processes Design & Simulation

L T P C

3 0 0 3

Module 1:

Introduction to Simulation, Systems, Models, Data Collection and Analysis, Monte Carlo Simulation, Types of system simulation, Decision making with simulation, applications.

Module 2:

Queuing Models: Characteristics of queuing systems, queuing notions, long run measures of performance of queuing systems, steady state behavior of Markovian models (M/G/1, M/M/1, M/M/c) overview of finite capacity and finite calling population models, Network of queues. Monte Carlo simulation and its applications in Manufacturing Processes Simulation.

Module 3:

Generation of (Pseudo) random numbers, Probability distributions and Probability densities, Sampling from probability distribution: Inverse method, Convolution method, Acceptance rejection method.

Module 4:

Discrete Simulation, Continuous Simulation, Combined Simulation, Problem formulation, Mechanics of discrete simulation- discrete events, representation of time, generation of arrival pattern, simulation examples, simulation programming tasks, gathering statistics, measuring utilization and occupancy recording distributions and transit times, case studies.

Module 5:

Steps to build a useful model of input data, data collection, verification of simulation models, validation process, simulation software, classification of simulation software and desirable software features, comparison of simulation packages with programming languages, general purpose simulation packages, object oriented packages, case studies.

Module 6:

Analysis of Simulation output, Importance of the variance of the sample mean, Procedure for estimating variance, Subinterval method, Replication Method, Regenerative method; Variance reduction techniques, Start up policies, Stopping rules, Statistical inferences,

Design of experiments, Manufacturing Processes, Simulation case studies .

TEXT BOOKS:

1. Law A. M., and Kelton, W. D., “Simulation Modeling and Analysis”, 3rd edition, McGraw-Hill.
2. Gordon G, “System Simulation”, 2nd edition, PHI Learning.

Reference Books:

1. Trivedi K. S., “Probability and Statistics with Reliability, Queueing, and Computer Science Applications”, PHI.
2. Wadsworth G. P., and Bryan, J. G., “Introduction to Probability and Random Variables”, McGraw-Hill.
3. Bernard, “Theory Of Modeling and Simulation”
4. Viswandhan N. and Narhari Y., “Performance Modeling of Automated Manufacturing Systems”, PHI India.
5. Fishwick P., “Simulation Model Design and Execution”, Prentice Hall.
6. Ross, S., “Simulation”, Academic Press.

ME-805 CNC Technology & Programming

L T P C
3 0 0 3

1. **FUNDAMENTALS OF CNC MACHINES:** Introduction to Computer Numerical Control: CNC Systems – An Overview of Fundamental aspects of machine control, Different types of CNC machines – Advantages and disadvantages of CNC machines.
2. **CONSTRUCTIONAL FEATURES OF CNC MACHINES AND RETROFITTING:** Features of CNC Machines: Structure, Drive Mechanism, gearbox, Main drive, feed drive, Spindle Motors, Axes motors. Timing belts and pulleys, Spindle bearing, Slide ways, Re-circulating ball screws – Backlash measurement and compensation, linear motion guide ways. Tool magazines, ATC, APC, Chip conveyors. Retrofitting of Conventional Machine Tools
3. **CONTROL SYSTEMS, FEED BACK DEVICES AND TOOLING:** Description of a simple CNC control system. Interpolation systems. Features available in a CNC system – introduction to some widely used CNC control systems. Types of measuring systems in CNC machines – Incremental and absolute rotary encoders, linear scale – resolver – Linear induction – Magnetic Sensors for Spindle Orientation. Qualified and pre-set tooling – Principles of location – Principles of clamping – Work holding devices.
4. **CNC PART PROGRAMMING:** Part Program Terminology-G and M Codes – Types of interpolation Methods of CNC part programming – Manual part programming – Computer Assisted part programming – APT language – CNC part programming using CAD/CAM-Introduction to Computer Automated Part Programming.
5. **ECONOMICS AND MAINTENANCE:** Factors influencing selection of CNC Machines – Cost of operation of CNC Machines – Practical aspects of introducing CNC machines in industries – Maintenance features of CNC Machines – Preventive Maintenance, Other maintenance requirements.

Books:

1. Computer Numerical Control Machines — P. Radahkrishnan
2. CNC Machines — M.S. Sehrawat and J.S. Narang
3. CNC Programming Handbook — Smid Peter
4. Automation, Production systems and Computer Integrated Manufacturing — M.P. Groover

5. Computer Integrated Manufacturing Paul Ranky

ME-806 CAD/CAE LAB

L T P C

0 0 4 2

CAD

i) CAD Introduction.
ii) Sketcher
iii) Solid modeling –Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc
iv) Surface modeling –Extrude, Sweep, Trim ..etc and Mesh of curves, Free form etc
v) Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
vi) Assembly-Constraints, Exploded Views, Interference check
vii) Drafting-Layouts, Standard & Sectional Views, Detailing & Plotting.

Exercises in Modeling and drafting of Mechanical Components - Assembly using Parametric and feature based Packages like Autodesk Inventor® / HyperWorks® etc available at Centre of Excellence for Design.

CAE

Analysis of Mechanical Components – Use of Software like Hyperworks® etc., Exercises shall include analysis of:-

i) Mold Flow Analysis
ii) Forming Analysis

Use of manufacturing simulation softwares like HyperWorks®/ Autodesk Inventor® etc. available at Centre of Excellence for Design.

ME-807 CAM LAB

L T P C

0 0 2 1

Objective: To train the students in manual and computer assisted part programming, tool path generation and control, operation and control of CNC machines tools.

List of Experiments

1. Manual part programming using G and M codes for Turning, step turning, Taper turning, thread cutting and radius turning on cylindrical components.

2. Programming and Simulation of machining using the following features.(i) Linear and Circular interpolation(ii) Pocket milling, slotting, peck drilling and other fixed canned cycles.
3. Given a component drawing to write the manual part programming and execute on CNC Lathe and Milling Machine.

List of facilities required

1. CNC Lathe with Fanuc® / Siemens® Control
2. CNC Milling Machine with Fanuc® / Siemens® control
3. Master CAM® / Machining module of Hyperworks® software
4. Computer Workstations

Programe Electives

ME-811 Computer Integrated Manufacturing

L T P C

3 0 0 3

Introduction

The meaning and origin of CIM- the changing manufacturing and management scene - External communication - islands of automation and software-dedicated and open systems-manufacturing automation protocol - product related activities of a company-marketing engineering - production planning - plant operations - physical distribution-business and financial management.

Components of CIM

Building blocks of flexible manufacturing system; Manufacturing Machines and their Design Consideration e.g. CNC Turn, CNC Mill etc., Pallet, CMM, Measuring Probes, Robots, Job Loading & Unloading Arm, Work Transfer stations, Assembly Stations, Automated Storage Retrieved System (ASRS), Material Handling Systems: Automated Guided Vehicles (AGV), Conveyers, Computer Control System. Mechatronics: Sensors, Actuators, Convertors, Modular Automation.

Shop Floor Control & Integration of Components

Shop floor control-phases -factory data collection system -automatic identification methods-Bar code & RFID technology-automated data collection system, Integration of manufacturing & business functions.

TEXT BOOK:

1. Nanua Singh "Systems Approach to Computer Integrated Design and Manufacturing" John Wiley & Sons, Inc
2. Mikell.P.Groover "Automation, Production Systems and computer integrated manufacturing", Pearson Education 2001.

REFERENCE BOOKS:

1. Nand K. Jha "Hand-book of Flexible Manufacturing Systems" Academic Press, 1991

2. Yorem koren, “Computer Integrated Manufacturing System”, McGraw-Hill, 1983.
3. Ranky, Paul G., “Computer Integrated Manufacturing”, Prentice Hall International, 1986.
4. David D.Bedworth, Mark R.Hendersan, Phillip M.Wolfe “Computer Integrated Design and Manufacturing”, McGrw-Hill.
5. Roger Hanman “Computer Intergrated Manufacturing”, Addison – Wesley, 1997.
6. Mikell.P.Groover and Emory Zimmers Jr., “CAD/CAM”, Prentice Hall of India Pvt. Ltd., New Delhi-1, 1998.
7. Kant Vajpayee S, “Principles of Computer Integrated Manufacturing”, Prentice Hall India, 2003.
8. Radhakrishnan P, Subramanyan S.and Raju V., “CAD/CAM/CIM”, 2nd Edition New Age International (P) Ltd., New Delhi.

ME-812 Automation in Manufacturing

L T P C
3 0 0 3

UNIT-I

Introduction, Definition and components of Automation, Economics of Automation, Automation for Productivity and cost reduction. Hard and soft Automation, FMS, CIM, Transfer Machines.

UNIT-II

Devices for conveying small components: Bowl feeders, Hopper, wiper blade, Pressure break Escapements mechanisms.

UNIT-III

Devices for Loading /unloading work pieces, Clamping Work pieces, Changing cutting tools, etc. Product Design for Automated Assembly, need for Automated Assembly. Roll of computers and sensors in Automation.

UNIT-IV

Control Engineering in Production System : Open loop and closed loop control systems, Mathematical modeling of dynamics systems, Transient for response analysis of control systems, Basic control actions, and different type of controllers; Pneumatic, hydraulic & electronic controllers; Stability analysis of control system.

References

1. Handbook of design, manufacturing & Automation : R.C. Dorf, John Wiley and Sons.
2. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
3. Industrial Automation : W.P. David, John Wiley and Sons.
4. Computer Based Industrial Control, Krishna Kant, EEE-PHI
5. An Introduction to Automated Process Planning Systems, Tiess Chiu Chang & Richard A. Wysk
6. Manufacturing assembly Handbook:- BrunoLotter
7. Anatomy of Automation, Amber G.H & P. S. Amber, Prentice Hall.
8. Performance Modeling of Automated Manufacturing Systems, Viswanandham, PHI
9. Automation by W. Buekinsham.

ME-813 INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS

L T P C

3 0 0 3

1. Introduction and Robot Kinematics

10

Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement – End effectors – Sensors.

Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.

2. Robot Drives and Control

09

Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers.

3. Robot Sensors

09

Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system.

4. Robot Cell Design and Application

09

Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial application of robots.

5. Robot Programming, Artificial Intelligence and Expert Systems

08

Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of

artificial intelligence – AI techniques – problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots.

TEXT BOOK:

1. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, "Robotics Control, Sensing, Vision and Intelligence", Mc Graw Hill, 1987.

REFERENCES:

1. Yoram Koren," Robotics for Engineers' Mc Graw-Hill, 1987.
2. Kozyrey, Yu. "Industrial Robots", MIR Publishers Moscow, 1985.
3. Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 1984.
4. Deb, S.R." Robotics Technology and Flexible Automation", Tata Mc Graw-Hill, 1994.
5. Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey," Industrial Robotics Technology, Programming and Applications", Mc Graw-Hill, Int. 1986.
6. Timothy Jordanides et al ,"Expert Systems and Robotics ", Springer –Verlag, New York, May 1991.

ME-814 Precision & Micro-machining

L T P C

3 0 0 3

UNIT-I

INTRODUCTION: basic definition, size scales, scaling analysis, technology change, Lithographic Processes- Optical and X-ray.

UNIT-II

PRECISION ENGINEERING AND PRACTICES: Definitions, Sources of Error, Basic Concepts of Machining, Machine Tool Variables- accuracy, stiffness, spindle vibration, flatness, straightness, and smoothness of motion, 1-2 DOF systems, Feedback Variables, Cutting Tool Variables, Workpiece Variables, Environment Effects and Thermal Errors.

UNIT-III

INTRODUCTION TO MACHINING ANALYSIS: geometry of Cutting Edge, Energy Models, Comparison with Micro-scale Machining.

DIAMOND MICROMACHINING: Introduction, Diamond as a Tool Material, Compatible Materials, Diamond Performance, Diamond Machining, Micro-mechanical Applications, Diamond Machining as a Micro-mechanical Process Research Method, Ductile Regime Grinding MICRO-ECM, MICRO-EDM etc.

MICROMILLING: Micro-milling Tools, Process Results and Micro-milling Applications-micromechanically

milled X-ray masks, micro-milled mask materials, Mask Absorption

Quantification, Exposure Quantification.

MICRODRILLING: Micro-drilling and Macro-drilling Techniques.

LASER MICROMACHINING: laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation.

LIGA, S-LIGA

UNIT-IV

Micro welding: Micro welding in similar and dissimilar materials; welding processes like ultrasonic, EB, LB; applications.

Micro casting: Casting processes like vacuum, semi-solid state; applications.

Processing of Integrated Circuits, Clean rooms, crystal growing and shaping of wafers, Etching, Photo and other lithography techniques, Impurity introduction, Thermal oxidation, CVD, Metallisation etc. IC packaging

References

1. Kluwer, "A new direction in manufacturing", Academic Publishers, London, 1997
2. Kalpakjian, "Manufacturing engineering & technology", Addison – Wesley, 4nd Edition
3. Debitson A., "Hand book of precision engineering"
4. J. A. McGeough, "Advanced methods of machining", Chapman and Hall, London, 1988
5. Jain V. K., "Introduction to micromachining", Narosa Publishers
6. M. Madou, "Fundamentals of microfabrication"
7. Momber A. W. and Kovacevic R., "Principles of water jet machining", Springer – Verlag
8. R. L. Murthy., "Precision engineering manufacturing", New Age International
9. G. Chryssolouris, "Laser machining – theory and practice", Springer Verlag, New York,1991

ME-821 Advanced Metal Forming

L T P C

3 0 0 3

UNIT I:

Fundamentals of Metal Forming: Classification of forming processes, mechanism of metal forming, temperature of metal working, hot working, cold working, friction and lubricants.

UNIT II:

Rolling of metals: Rolling processes, forces and geometrical relationship in rolling, simplified analysis, rolling load, rolling variables, theories of cold and hot rolling, problems and defects in rolling, torque and power calculations.

UNIT III:

Forging: Classification of forging processes, forging of plate, forging of circular discs, open die and closed-die forging, forging defects, and powder metallurgy forging.

UNIT IV:

Extrusion: Classification, Hot Extrusion, Analysis of Extrusion process, defects in extrusion, extrusion of tubes, production of seamless pipes.

UNIT V:

Drawing: Drawing of tubes, rods, and wires: Wire drawing dies, tube drawing process,analysis of wire, deep drawing and tube drawing.

UNIT VI:

Sheet Metal forming: Forming methods, Bending, stretch forming, spinning and Advanced techniques of Sheet Metal Forming, Forming limit criteria, defect in formed parts. Advanced Metal forming processes: HERF, Electromagnetic forming, residual stresses, in-process heat treatment and computer applications in metal forming.

UNIT VII:

Introduction to Press tool design: Design of various press tools and dies like piercing dies, blanking dies, compound dies and progressive blanking dies, design of bending, forming and drawing dies.

UNIT VIII:

Analysis of Forming Process, Slab method, Upper & lower bound, FEM based simulation, slip line theory, Use of CAE platform for Die Design & Simulation.

Text Books:

1. Mechanical Metallurgy / G.E. Dieter / Tata McGraw Hill, 1998. III Edition2. Principles of Metal Working / Sunder Kumar

References:

1. Principles of Metal Working processes / G.W. Rowe

2. ASM Metal Forming Hand book

ME-822 Welding & Allied Processes

L T P C

3 0 0 3

Welding Power Sources:
Types of power sources, External V-I characteristics for constant current and constant voltage power sources, Rectifiers, Solid-state Rectifiers, Inverter systems, Duty cycle.

Arc welding consumables:
Types of electrodes, AWS and Indian system of classification and coding of covered electrode for mild steel, Shielding gases and associated mixtures.

Metal transfer:
Short circuit/ dip transfer, Free flight, Globular type, Spray type, Forces affecting metal transfer, Weld bead geometry and shape factors, Weld dilution.

Arc welding processes:
Electric arc welding principle, MIG: -welding equipment and processes, shielding gas, types of metal transfer. Tungsten inert gas arc welding (GTAW): - welding equipment, electrodes, inert gases and torches. Submerged arc welding (SAW):- principle of processes, applications, fluxes and welding electrodes used. CO2 welding: - difference from MIG welding, Principle of operation, equipment, welding parameters and applications.

Solid state welding:
Introduction, main features and applications of Ultrasonic welding, Friction welding and Explosive welding.

Welding of plastics:
Difficulties in welding of Plastics, Processes for welding of Plastics.

Weldability of specific Materials:
Stainless Steel, Aluminum and Cast Iron.

Surfacing and metal spraying:
Surfacing methods such as SMAW, MIG, TIG, SAW. Thermal spraying: Introduction, Procedures, Applications, Advantages and Disadvantages.

Thermal cutting of metals:
introduction, types, principle and operation of flame and plasma cutting.

Under water Welding:
Introduction, methods and applications

Automation in Welding:
Introduction, Semiautomatic welding, Automatic welding, Welding mechanization, Flexible Automated Welding, Robotic welding, Types of Welding Robots, Robot Selection Mechanics, Joint tracking system.

Reference books:

1. Modern welding technology:- carry H. B. (PH).
2. Welding technology :- A. C. Devis
3. Welding and welding Technology :- Little (TMH)
4. Welding technology :- R. S. Parmar
5. AWS- welding handbook(IV – VI) Edition

ME-823 Advanced Casting Processes

L T P C

3 0 0 3

UNIT-I

Production of Moulds and Cores : Mould production - equipment for moulding, moulding technique - pattern utilisation, hand and machine compaction, machine moulding, mould drying and hardening. Cores and core making - core boxes, compaction, core hardening, closing of moulds.

UNIT-II

Melting and Pouring : Melting Practice : Classification of melting furnaces, brief description of construction and operation of various furnaces - cupola and its design, electric arc furnaces, electric induction furnaces. Melting charge, melting conditions, melting losses, special melt treatment, melt quality control and recent development in metal melting. Pouring: Metal temperature, pouring equipment and techniques.

UNIT-III

Details Study of Following Casting Techniques: Shell moulding - Basic operation, production systems, characteristics of shell moulded casting and D-process. Investment Casting - expandable pattern process. Pattern production, investment, pattern removal and firing, casting. Factor influencing casting quality characteristics of precision investment casting. Investment casting from permanent casting. Die-casting - Gravity die-casting, pressure-die casting, die-casting machines, casting techniques, characteristics of die - castings. Centrifugal casting - Fundamental principles, methods production techniques, characteristics of centrifugal casting.

UNIT-IV

Solidification of Castings : Crystallization and development of cast structure - Nucleation, Growth and dendrite growth, independent nucleation, eutectic freezing, paratactic relations, structure of castings - significance and practical control cast structure, grain shape and orientation, grain size, refinement and modification of cast structure. Concept of progressive and directional solidification, solidification time and derivation of Chvorinov's equation influence of mould characteristics and cast metal. Properties on solidification, process numerical methods for heat flow analysis.

UNIT-V

Feeding of Castings : Feeding characteristics of alloys, geometric influences on solidification. Methods of the feeding of castings - cost and concept of yield, orientations, gating technique, casting temperature and pouring speed, design and location of feeder heads. Aids to feeder head efficiency, junction of feeder head and casting, use of padding, chills and insulators.

REFERENCE :

1. Beeley P.R., "Foundry Technology" (Buttersworth)

2.Heine and Rosenthal, “Principles of Metal Cutting” (TMH)
3. “Metal Casting” ASME Handbook

4.P.C.Mukherji, “Metal Casting Technology”

ME-831 MEMS & NEMS

L T P C

3 0 0 3

UNIT-I

Introduction, History, Development and need of Micro-Electro-Mechanical Systems. Overview

of MEMS technology.

UNIT-II

Different electro-physical processes used for machining – dealing with MEMS materials; relevant non-conventional processes; IC fabrication processes used for MEMS.

UNIT-III

MEMS sensors and actuators; Mechanical process techniques and process models for micromachining;

UNIT-IV

Fabrication processes and design of the process sequences; Agile Prototyping of design and manufacturing processes in micro-machining and computer based design.

UNIT-V

Reliability and process control of micro manufacturing processes; Introduction and exposureto nano-technology processes and systems.

References

1. "RF MEMS and Their Applications", Vijay Varadan, K. J. Vinoy, K. A. Jose, Wiley,2002.

2. "RF MEMS: Theory, Design, and Technology", Gabriel M. Rebeiz, Wiley, 2003.

3. Marc Madou, *Fundamentals of Microfabrication*, 2nd Edition, CRC Press, 2002.
4. C. Liu, *Foundations of MEMS*
5. N. Maluf, *An Introduction to Microelectromechanical Systems Engineering*
6. J. Pelesko & D. Bernstein, *Modeling MEMS and NEMS*

ME-832 Experimental Stress Analysis

L T P C

3 0 0 3

Unit-1

BASIC ELASTICITY: Laws of stress transformation, principal stresses and principal planes, Cauchy's stress quadric. Strain analysis, strain equations of transformation, Principal strain, Cauchy's strain quadric, stress-strain relationship.

TWO DIMENSIONAL PHOTO ELASTICITY: Stress optic law, optics of polariscope, plane and circular polariscope, dark and light field arrangements, fringe multiplication, fringe sharp ending, compensation techniques, commonly photo-elastic materials.

Unit-2

THREE DIMENSIONAL PHOTO ELASTICITY: Neuman's stain optic relationship, stress freezing in models, materials for three-dimensional photo-elasticity, shear-difference method of stress separation.

BI-REFRINGENT COATINGS: Sensitivity reinforcing effects and thickness of bi-refringent coatings.

Unit-3

ELECTRIC RESISTANCE STRAIN GAUGES: Gauge construction and installation, temperature compensation, gauge sensitivity, gauge factor, corrections for transverse strain effects. Factors affecting gauge relation, Rosettes, Rosettes analysis, potentiometer and wheatstone bridge circuits for strain measurements.

Unit-4

BRITTLE COATINGS: Introduction, coatings, stresses and failure theories, different types of crack patterns, crack detection, Composition of brittle coatings, coating cure, influence of atmospheric conditions, and effect of biaxial stress field.

TEXT BOOKS

1	Experimental Stress Analysis	Dally & Ralley
2	Introduction to Photo Mechanics	Durellil & Hiley
3	Photo elasticity: Principles and Methods	Jesseop & Harris
4	Theory of Plasticity	J. Chakrabarty

ME-832 Finite Element Method

L T P C
0 0 0 3

Unit-1
FUNDAMENTAL CONCEPTS: Introduction, Historical background, stresses and equilibrium, boundary conditions, strain-displacement relations, stress-strain relations, temperature effects, Rayleigh-Ritz Method, Galerkin's Method, Saint Venant's Principle, Matrix algebra, Gaussian Elimination. Choice of mesh, mesh data in numerical form, generation of mexh data, mesh modification.

Unit-2
ONE -DIMENSIONAL PROBLEMS: Introduction, Finite element Modeling, Co-ordinates and Shape Functions, Potential energy approach, The Galerkin Approach, Assembly of Global stiffness matrix and load vector, Finite element equations; Treatment of boundary conditions, quadratic shape functions, Temperature effects.

Unit-3
TRUSSES: Introduction, plane trusses, three dimensional trusses, assembly of global stiffness matrix for the banded and skyline solution.
TWO- DIMENSIONAL PROBLEMS: Introduction, finite element modeling, constant strain triangle (CST), Problem modeling and boundary conditions.
AXISYMMETRIC SOLIDS SUBJECTED TO AXISYMMETRIC LOADING: Introduction, Axisymmetric formulation, finite element modeling: Triangular elements, Problem modeling and boundary conditions.

Unit-4
TWO -DIMENSIONAL ISOPARAMETRIC ELEMENTS AND NUMERICAL INTEGRATION: Introduction, The fournode quadrilateral, Numerical Integration, Higher order element, Problem related to beams.
BEAMS AND FRAMES: Introduction, finite element formulation, load vector, boundary considerations, shear force and bending moment beams on elastic supports, plane frames, three dimensional frames.

Textbooks:

1. Introduction to Finite Elements in Engineering Tirupathi, R. ,Chandrupatle & Ashoka D. Belegundu
2. An Introduction to Finite Element Method J.N. Reddy
3. Finite Element Analysis -Theory and Programming C.S. Krishnamurthy

4. The Finite Element Method in Engineering S.S. Rao
5. Finite Element Methods for Engineers Roger T.Fennee
6. Finite Element Analysis in Engg. Design Rajoebaron

ME-841 Manufacture of Plastic Products

L T P C

3 0 0 3

UNIT-I

Introduction: polymeric materials, Engineering plastics, Polymer alloys, Selection of plastics.

UNIT-II

Mechanical properties, Degradation, Wear resistance, Frictional properties, Special properties, Structural features, Expanded plastics, Plastics as packaging material.

UNIT-III

Theoretical aspects; Visco-elastic behaviour, Mathematical models for visco-elastic behaviour,

Deformation behaviour of plastics, Reinforced plastics.

UNIT-IV

Analysis of polymer melt flow; Newtonian and non Newtonian fluid flow, Flow in circular section, Flow in rectangular section etc.

UNIT-V

Overview and analysis of various plastics forming operations; Extrusion, Injection moulding, Thermo-forming, Calendaring, Compression moulding, Blow moulding, Transfer moulding, Processing of reinforced plastics, Die design for simple components.

References

1. James F. Stenvension, Innovation in Polymer Processing Moulding, Hanser Publishers, New York, 1996.
2. Donald V. Rosato, Injection Moulding Handbook, International Thomson Publishing Company, 1985.
3. Friedhelm Henson, Plastics Extrusion Technology, Hanser Publishers, New York,1988.
4. Brunt Strong, Plastics: Materials and Processing, Prentice-Hall, New Jersey, 1996.
5. William J.Patton, Plastics Technology : Theory, Design and Manufacture, Prentice Hall
6. A Brent Strong, Plastics : Materials and Processings, Prentice Hall

ME-842 Rapid Prototyping & Tooling

L T P C

3 0 0 3

1. Introduction

07

Need - Development of RP systems – RP process chain - Impact of Rapid Prototyping and Tooling on Product Development – Benefits- Applications – Digital prototyping - Virtual prototyping.

2. Liquid based and solid based rapid prototyping systems

10

Stereolithography Apparatus, Fused deposition Modeling, Laminated object manufacturing, Three dimensional printing: Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

3. Powder based rapid prototyping systems:

10

Selective Laser Sintering, Direct Metal Laser Sintering, Three Dimensional Printing, Laser Engineered Net Shaping, Selective Laser Melting, Electron Beam Melting: Processes, materials, products, advantages, applications and limitations – Case Studies.

4. Reverse Engineering and CAD Modeling

10

Basic concept- Digitization techniques – Model Reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data Requirements – geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation.

5. Rapid Tooling

08

Classification: Soft tooling, Production tooling, Bridge tooling; direct and indirect – Fabrication processes, Applications. Case studies - automotive, aerospace and electronic industries.

TEXT BOOK:

1. Rapid prototyping: Principles and applications, second edition, Chua C.K., Leong K.F., and Lim C.S., World Scientific Publishers, 2003.
2. Rapid Tooling: Technologies and Industrial Applications, Peter D.Hilton, Hilton/Jacobs, Paul F.Jacobs, CRC press, 2000.

REFERENCE:

1. Rapid prototyping, Andreas Gebhardt, Hanser Gardener Publications, 2003.
2. Rapid Prototyping and Engineering applications : A tool box for prototype development, Liou W.Liou, Frank W.Liou, CRC Press, 2007.
3. Rapid Prototyping: Theory and practice, Ali K. Kamrani, Emad Abouel Nasr, Springer, 2006

ME-843 Tool Engineering

L	T	P	C
3	0	0	3

1. **Introduction to Tool design** **8**

   Introduction –Tool Engineering – Tool Classifications– Tool Design Objectives – Tool Design in manufacturing- Challenges and requirements- Standards in tool design-Tool drawings -Surface finish – Fits and Tolerances - Tooling Materials- Ferrous and Non ferrous Tooling Materials- Carbides, Ceramics and Diamond -Non metallic tool materials-Designing with relation to heat treatment

2. **Design of cutting Tools** **9**

   Mechanics of Metal cutting –Oblique and orthogonal cutting- Chip formation and shear angle - Single-point cutting tools – Milling cutters – Hole making cutting tools-Broaching Tools - Design of Form relieved and profile relieved cutters-Design of gear and thread milling cutters

3. **Design of Jigs and Fixtures** **10**

   Introduction – Fixed Gages – Gage Tolerances –selection of material for Gages – Indicating Gages – Automatic gages – Principles of location – Locating methods and devices – Principles of clamping – Drill jigs – Chip formation in drilling – General considerations in the design of drill jigs – Drill bushings – Methods of construction – Thrust and Turning Moments in drilling - Drill jigs and modern manufacturing- Types of Fixtures – Vise Fixtures – Milling Fixtures – Boring Fixtures – Broaching Fixtures – Lathe Fixtures – Grinding Fixtures – Modular Fixtures – Cutting Force Calculations.

4. **Design of Forming Tools** **10**

Types of Sheet Metal Dies –Method of Die operation–Clearance and cutting force calculations- Blanking and Piercing die design – Pilots – Strippers and pressure pads-Presswork materials – Strip layout – Short-run tooling for Piercing – Bending dies – Forming dies – Drawing dies-Design and drafting. Design of Bulk forming dies and moulds for metals and plastics.

5. Tool Design for CNC machine tools
8

Introduction –Tooling requirements for Numerical control systems – Fixture design for CNC machine tools- Sub plate and tombstone fixtures-Universal fixtures– Cutting tools– Tool holding methods– Automatic tool changers and tool positioners – Tool presetting– General explanation of the Brown and Sharp machine

REFERENCES:

1. Cyrll Donaldson, George H.LeCain, V.C. Goold, “Tool Design”, Tata McGraw Hill Publishing Company Ltd., 2000.
2. E.G.Hoffman,” Jig and Fixture Design”, Thomson Asia Pvt Ltd, Singapore, 2004
3. Prakash Hiralal Joshi, “Tooling data”, Wheeler Publishing, 2000
4. Venkataraman K., “Design of Jigs, Fixtures and Presstools”, TMH, 2005
5. Haslehurst M., “Manufacturing Technology”, The ELBS, 1978

ME-851 / Product Design & Development (Pre approved course)

L T P C

3 0 0 3

Product definition, New product development concept, product development process, consumer behavior, identifying customer needs. Establishing product specification, concept generation, concept selection and product architecture. Industrial design, design for manufacturing prototyping, Economic analysis of new products. Test marketing and commercialization of new products.

Books Recommended

Chitle A. K and Gupta R.C, Product Design and Manufacturing, PHI

Saunders, M.S.and Mc Cornic E.J., 'Human Factors in Engineering & Design', McGraw Hill.

Ulrich K. T and Eppinger S.D, Product Design and Development, Mc Graw Hill

ME-861 Industrial Tribology

L T P C

3 0 0 3

1. **Introduction:** Tribology, Types of engineering contacts: conforming and non-conforming, Surface interactions and characterization, micro and nanotribology, surface roughness measurement techniques, surface energy and flash temperature theory.
2. **Friction**: Types, Laws of sliding friction, concept of adhesion, Models of asperity deformation, measurement of friction, friction of metals ceramics and Polymers.
3. **Wear:** Laws of wear, Classifications, wear models, factors affecting wear, ASTM standards for wear measurement.
4. **Viscosity:** Basic definition, conversions, dynamic viscosity, Measurement, variation with temperature, ASTM Charts, Viscosity index, Grade of oil.
5. **Lubrication Theories:** Lubrication regimes, viscous flow and viscometry, Reynold's equation, hydrodynamic lubrication, hydrostatic lubrication, elasto-hydrodynamic lubrication, boundary lubrication, squeeze films, turbulent lubrication.

Text Books:

1. Friction and Wear of Engineering Materials — I.M. Hutchings, Edwar Arnold, London
2. Friction and Lubrication — E.P. Bowden and Tabor
3. Fundamentals of Tribology — Basu, Sengupta & Ahuja
4. Engineering Tribology — Stachowiak & Bachelor
5. Principles and Applications of Tribology — Bhushan B.
6. Basic Lubrication Theory — A Comeron
7. Friction Wear & Lubrication Kenneth — C.Ludema
8. Engineering Tribology — J.A.Williams
9. Applied Tribology — Khonsari
10. Friction and Wear of Materials — Rabinowicz
11. Fundamentals of Fluid Film Lubrication — Hamrock, Schmid, Jacobson

ME-862 Reliability Centric Maintenance

L T P C

3 0 0 3

UNIT – I

Reliability: Definition, failure data analysis, Mean failure rate, mean time to failure (MTTF), mean time between failures (MTBF), hazard rate, Bathtub curve. Use of Weibull probability chart for assessing characteristics life, guarantee period etc.

UNIT –II

System Reliability: Series, parallel and mixed configuration; Simple problems. Reliability improvement: Techniques, use of Pareto analysis-Design for reliability, redundancy unit and stand by redundancy, Optimization of reliability, Failure modes, Event Tree and Fault Tree analysis.

UNIT –III

Introduction: Maintenance Objectives and Functions; Maintenance Organization and Administration of Maintenance Systems. Need of planned maintenance. Maintenance policies; Breakdown, time based maintenance: Block replacement, age replacement and periodic replacement policy. Corrective and Preventive maintenance. Maintenance planning, Scheduled maintenance. Cost of maintenance versus Cost of equipment and production delays. Inspection: Inspection intervals, Inspection reports, card history system.

UNIT – IV

Predictive maintenance, Equipment wears records, standards. Equipment used in predictive maintenance. Computerized maintenance,, Total Productive Maintenance. Methods of condition monitoring, Non-destructive testing: Liquid Penetrate, Magnetic particles, Ultrasonic testing, and Vibration analysis. Oil analysis, Radiographic testing.

Text Books:

1. Reliability Engineering by A.W. Von, PHI, ND.
2. Mechanical Reliability by L.S. Srinath, Published by EWP.
3. Maintenance Planning and Control by Enthory Kelly, EWP-NWP, ND.

References:

1. Smith, D.J. “Reliability Maintainability and Risk; Practical methods for engineers”,Butterworth-Heinemann, New Delhi, 2001
2. Dhillon,B.S. “Maintainability, Maintenance and Reliability for Engineers”, CRC Press 2006
3. Pha, H. “ Handbook of Reliability engineering”, Springer Publication, 2003.
4. Dhillon,B.S “Engineering maintenance; a modern approach”, CRC Press, 2002
5. Mobley, R.K. “Maintenance Fundamentals”, 2nd Edition, Butterworth-Heinemann, 2004
6. Brauer, R.L. “Safety and Health for Engineers”, John Wiley Sons, 2006

Reliability Maintenance and Risk, Elsevier Science and Technology Books, 1997

ME-863 Composite Materials & Processing

L T P C
3 0 0 3

1. Introduction: Classifications of Engineering Materials, Concept of composite materials, Matrix materials, Functions of a Matrix, Desired Properties of a Matrix, Polymer Matrix (Thermosets and Thermoplastics), Metal matrix, Ceramic matrix, Carbon Matrix, Glass Matrix etc. Types of Reinforcements/Fibers: Role and Selection or reinforcement materials, Types of fibres, Glass fibers, Carbon fibers, Aramid fibers , Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes etc., Mechanical properties of fibres. Material properties that can be improved by forming a composite material and its engineering potential

2. Various types of composites: Classification based on Matrix Material: Organic Matrix composites, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC); Classification based on reinforcements: Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Laminar Composites, Particulate Composites, Comparison with Metals, Advantages & limitations of Composites

3. Fabrication methods: Processing of Composite Materials: Overall considerations, Autoclave curing, Other Manufacturing Processes, Fiber-only performs, Combined Fiber-Matrix performs, Manufacturing Techniques: Tooling and Specialty materials, Release agents, Peel plies, release films and fabrics, Bleeder and breather plies, bagging films

4. Testing of Composites: Mechanical testing of composites, tensile testing, Compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing etc.

5. Characterisations techniques: SEM, TEM, XRD, DSC, DTA, TGA, DMA etc.

Textbooks:

1. Materials characterisation, Vol. 10, ASM hand book
2. Mechanical Metallurgy by G. Dieter Mc-Graw Hill
3. Thermal Analysis of Materials by R.F. Speyer, Marcel Decker
4. Engineering Materials: Polymers, Ceramics and Composites A.K Bhargava Prentice Hall of India