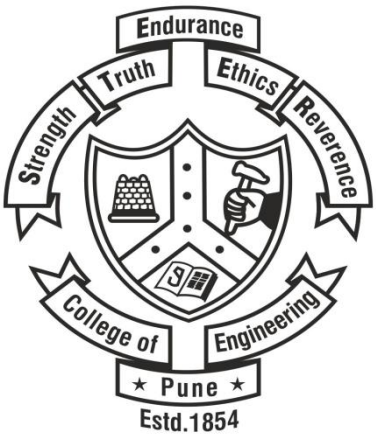
COLLEGE OF ENGINEERING, PUNE

(An Autonomous Institute of Govt. of Maharashtra)

DEPARTMENT OF MANUFACTURING ENGINEERING AND INDUSTRIAL MANAGEMENT



CURRICULUM STRUCTURE

Third Year B.Tech. (Manufacturing Science and Engineering)
(Revision: A.Y. 2020-21, Effective from: A.Y. 2022-23)

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Program Education Objectives (PEOs):

The Undergraduate students will demonstrate:

PEO-1: **Core Competency / Breadth**: Demonstrate professional engineering competence to real life problems and compete successfully using principles of manufacturing and time and quality management in the design and manufacture of products and services while working in multidisciplinary areas whose solutions lead to significant societal benefits.

PEO-2: Preparation / Application: Advance professionally and/or pursue higher education and /or turn entrepreneur based on knowledge of mathematics, basic sciences, engineering and humanities principles.

PEO-3: Learning Environment / Professionalism: Exhibit professionalism, ethical attitude, communication skills, soft skill, life skill, teamwork in their profession and adapt to current trends by engaging in lifelong learning.

Program Outcomes (POs):

The Undergraduate Students will demonstrate:

PO1 Graduates will apply the basic knowledge of mathematics, science, engineering and humanities to Production Engineering field

PO2 Graduates will have the ability to define the problems and provide solutions by designing and conducting experiments, interpreting and analyzing data for manufacturing

PO3 Graduates will design manufacturing systems that would encompass machining science and technology, production processes, metal forming, tool and die design with the fully acquaintance with engineering thermodynamics and heat transfer, theory of machines, strength of material and would meet specifications and requirements as demanded by industries

PO4 Graduates will apply concepts of design and tooling for manufacturing, Kinematics of Machine Elements, Quality Control, modelling of manufacturing systems to solve production engineering problems.

PO5 Graduates understand manufacturing technologies like Computer Controlled Processes and Industrial Engineering, Production Management, SCLM, Total Quality Management concepts and Simulation tools.

PO6 Graduates will be able to apply engineering solutions in global and societal contexts.

PO7 Graduates will understand quantitative modeling and analysis of a broad array of system-level decision problems concerned with economic efficiency, work design, productivity and quality with environmental focus.

PO8 Graduates will be capable of self-education and clearly understand the value of achieving perfection in their professional endeavours.

PO9 Graduates will participate as members of engineering and science laboratory teams, as well as members of multidisciplinary design teams.

PO10 Graduates will be proficient in English language in both verbal and written forms which will enable them to express their ideas and views in industry.

PO11 Graduates will have the ability to choose and apply appropriate resource management technique/s so as to optimally utilize resources in manufacturing systems.

PO12 Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.

Correlation between the PEOs and PO's/PSO's

Program Objectives		**Program Outcome**												**Program Specific Outcomes**		
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**PSO 1**	**PSO 2**	**PSO 3**
PEO's	**I**	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓
	II	✓	✓	✓	✓	✓	✓					✓	✓	✓		
	III	✓	✓				✓		✓	✓	✓		✓			✓

Program Specific Outcomes:

After completion of the program, the graduates should be able to:

PSO1 Apply knowledge of Manufacturing Systems, Industrial Engineering and Analytical Techniques to solve real world problems.

PSO2 Apply knowledge of Design, Machine Tools, Measurement Systems, Quality Control and Management Systems, Ergonomics and Reliability to identify, formulate and solve complex engineering problems.

PSO3 Design, Develop and Manufacture innovative products/systems using emerging manufacturing and computing technologies like CAD/CAM/CIM, Additive Manufacturing, Robotics, Machine Learning, Artificial Intelligence, Enterprise Resource Planning (ERP)

UG Program Structure of B. Tech. (Manufacturing Science and Engineering)

List of Abbreviations:

Abbreviation	Title	No of courses	Credits	% of Credits
BSC	Basic Science Course	9	27	16.26
ESC	Engineering Science Course	5	18	10.89
MLC	Mandatory Learning Course	4	0	0
SLC	Self Learning Course	2	5	3.02
HSMC	Humanities/Social Sciences/Management Course	7	9	5.4
LLC	Liberal Learning Course	1	1	0.6
SBC	Skill Based Course	7	17	10.24
IFC	Interdisciplinary Foundation Course	2	4	2.40
IOC	Interdisciplinary Open Course	3	6	3.61
DEC	Department Elective Course	2	6	3.61
PCC	Program Core Course	19	56	33.73
LC	Laboratory Course	17	17	10.24
		78	166	100

UG Program Structure (B.Tech.]
Manufacturing Science and Engineering

Semester V [M-Group]

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	MLC	ML-21002	Environmental Studies	1	0	0	0
2	IFC		Interdisciplinary Foundation Course III	1	0	2	2
3	HSMC		Humanities Open Course – I • English Language Proficiency-I • Finance for Engineers-I • Engineering Economics-I • Industrial Psychology-I • Japanese Language-I • German Language-I	2	0	0	2
4	SBC	MFG-22001	Advance Manufacturing & Simulation Lab	0	0	2	1
5	PCC	MFG-22002	Metrology and Quality Control	3	0	0	3
6	PCC	MFG-22003	Tool and Die Design	2	1	0	3
7	PCC	MFG-22004	Industrial Engineering and Management	2	0	0	2
8	PCC	MFG-22005	Product Design and Manufacturing	3	0	0	3
9	PCC	MFG-22006	Material Forming	3	0	0	3
10	PCC	MFG-22007	Kinematics and Dynamics of Machines	2	1	0	3
11	LC	MFG-22008	Process Planning and Tool Selection Lab	0	1	2	2
12	LC	MFG-22009	Metrology and Quality Control Lab	0	0	2	1
			Total Academic Engagement and Credits	**19**	**2**	**8**	**25**

For Other Department

			Interdisciplinary Foundation Course III	**L**	**T**	**P**	**Credit**
1	IFC	MFG(IF)-22001	Fundamentals of Robotics	**2**	**0**	**0**	**2**

Semester VI [M-Group]

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	BSC	MA-21001	Probability & Statistics for Engineers	2	1	0	3
2	MLC	ML-21001	Constitution of India	1	0	0	0
3	HSMC		• Humanities Open Course – II • English Language Proficiency-II • Finance for Engineers-II • Engineering Economics-II • Industrial Psychology-II • Japanese Language-II German Language-II	2	0	0	2
4	HSMC	HS-21001	Entrepreneurship Principles and Process	1	0	0	1
5	SBC	MFG-22010	Mini project ["D-S-P-T: Design-Simulate- Prototype-Test "]	0	0	4	2
6	IOC		Interdisciplinary Open Course-I	2	0	0	2
7	DEC		Department Elective -/Industry floated Course/Co-Taught Course	3	0	0	3
8	PCC	MFG-22011	Robotics and Intelligent Manufacturing	2	1	0	3
9	PCC	MFG-22012	Operations Research	3	0	0	3
10	PCC	MFG-22013	Manufacturing Automation	3	0	0	3
11	LC	MFG-22014	Manufacturing Automation Lab	0	0	2	1
			Total Academic Engagement and Credits	**19**	**2**	**6**	**23**

Department Elective-I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	DEC	MFG(DE)-22001	Supply chain and Logistics Management	3	0	0	3
2	DEC	MFG(DE)-22002	Reliability and Maintenance	3	0	0	3
3	DEC	MFG(DE)-22003	Facility Planning and Design	3	0	0	3
4	DEC	MFG(DE)-22004	Micro and Nano Manufacturing	3	0	0	3
5	DEC	MFG(DE)-22005	Advanced Joining Technology	3	0	0	3
6	DEC	MFG(DE)-22006	Design of Experiments and Optimization	3	0	0	3

For other Department

Sr. No.	Course Type	Course Code	Interdisciplinary Open Course-I	Teaching Scheme			Credits
				L	T	P	
1	IOC	MFG(IF)-22002	Reliability Engineering	2	0	0	2

Minors- Manufacturing Technology (Mechanical)

Semester	Course offered	Teaching Scheme			Credits
		L	T	P	
V	Precision Engineering	3	-	-	3
VI	Additive Manufacturing	3	-	-	3
VII	Manufacturing Automation	3	-	-	3
VIII	Industrial Design of Products	3	-	-	3

Minors- Manufacturing Technology (Civil/ENTC/Electrical/Instru/Comp/IT/Meta)

Semester	Course offered	Teaching scheme			Credits
		L	T	P	
V	Manufacturing Processes	3	-	-	3
VI	Engineering Economics and Operations Research	3	-	-	3
VII	Manufacturing Automation	3	-	-	3
VIII	Industrial Design of Products	3	-	-	3

Honors- Manufacturing Systems Engineering

Semester	Course offered	Teaching scheme			Credits
		L	T	P	
V	Precision Engineering	3	-	-	3
VI	Reliability and Maintenance Engineering	3	-	-	3
VII	Performance Modeling of Production Systems	3	-	-	3
VIII	Machine Tool Systems	3	-	-	3

Honors- Mechatronics

Semester	Course offered	Teaching scheme			Credits
		L	T	P	
V	Principles of Electronics	3	-	-	3
VI	Industrial Instrumentation and Control	3	-	-	3
VII	Mechatronics System Design	3	-	-	3
VIII	Fluid Power Systems and Factory Automation	3	-	-	3

Semester Wise Credit Distribution	Teaching Scheme			Credits
	L	T	P	
I	13	2	12	21
II	14	2	10	21
III	16	2	8	22
IV	17	2	8	22
V	19	2	8	25
VI	18	2	10	23
VII	17	2	4	20
VIII	2	0	20	12
Total Academic Engagement and Credits	**116**	**14**	**80**	**166**

Semester V

(ML-21002) ENVIRONMENTAL STUDIES

Teaching Scheme
Lectures: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Know importance of environment and conversant with environmental science,
2. Able to understand about Renewable and non-renewable natural resources and become aware about environmental issues related to the exploration of natural resources and development of the mankind.
3. Aware about means of Pollution
4. Learn role of professional in protecting the environment from degradation
5. Knowing techniques of Solid waste management and Disaster management
6. Aware about Social issues and the environment

Unit 1 **(4 Hrs)**

Multidisciplinary nature of environmental studies: Definition, scope and importance, need for public awareness.

Unit 2 **(6 Hrs)**

Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.

Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forest and tribal people.

Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dams-benefits and problems.

Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

Food resources: World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.

Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. Case studies.

Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification.

Role of an individual in conservation of natural resources. Equitable use of resources for sustainable lifestyles.

Unit 3 **(4 Hrs)**

Biodiversity and its conservation: Introduction – Definition: genetic, species and ecosystem diversity, Bio-geographically classification of India, Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values.

Unit 4 **(4 Hrs)**

Biodiversity and its conservation: Biodiversity at global, National and local levels. India as a mega-diversity nation. Hot-spots of biodiversity. Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts. Endangered and endemic species of India Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit 5 **(8 Hrs)**

Environmental Pollution: Definition, Cause, effects and control measures of :-a. Air pollution, b. Water pollution, c. Soil pollution, d. Marine pollution, e. Noise pollution, f. Thermal pollution, g. Nuclear hazards, Solid waste Management : Causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution. Pollution case studies. Disaster-management: floods, earthquake, cyclone and landslides.

Unit 6 **(7 Hrs)**

Social Issues and the Environment: From Unsustainable to Sustainable development, Urban problems related to energy, Water conservation, rainwater harvesting, watershed management, Resettlement and rehabilitation of people; its problems and concerns. Case Studies: Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies. Wasteland reclamation. Consumerism and waste products. Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act Wildlife Protection Act Forest Conservation Act Issues involved in enforcement of environmental legislation. Public awareness.

Textbooks:

- Environmental studies from crisis to cue R Rajgopalan, III edn. OUP ISBN no. 0-19-537393-X 2.
- Environmental Science, S C Santra, New Central Book Agency PVT LTD London ISBN no. 81-7381-404-X 3.
- Environmental Chemistry by De A.K., Wiley Eastern Ltd.

Reference Book:

- The Biodiversity of India by Bharucha Erach, Mapin Publishing Pvt. Ltd., Ahmedabad – 380 013, India, Email: mapin@icenet.net
- Handbook of Environmental Laws by Trivedi R.K., Rules Guidelines, Compliances and Standards, Vol I and II, Enviro Media.

(SBC) (MFG-22001) Advance Manufacturing & Simulation Lab

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Term work - 50 Marks
Practical – 50 marks

Course Outcomes:
At the end of the laboratory work, students will demonstrate the ability to

1. To understand the design methodology of various press tools, Jigs, Fixtures, press tools and dies.
2. To acquire proficiency in the design and development of required tooling and dies.
3. To understand use of simulation tool for analysis of press tools and dies.
4. To enable the students to Design & drawing of dies for shearing, forming operation.
5. To enable the students to effectively use CAD/Simulation software for die design, Casting and forging.

List of Experiments / Assignments:

1. Detail design, drawing and simulation of die for Blanking/Punching/Drawing operation. (Use of CAD/simulation software desirable)
2. Simulation of casting and Molding Process (Use of CAD/simulation software desirable)
3. Prototype fabrication using Digital Fabrications facilities.
4. Hands on Laser cutter and engraver for complex profile fabrication
5. Hands on CNC Router
6. Hands on hybrid micro-machining system
7. Hands on Non-Conventional Machining Processes
8. Demonstration of prototype fabrication using FAB LAB facilities
9. Hands on Laser cutter and engraver for complex profile fabrication at FAB LAB
10. Hands on CNC wood router at FAB LAB

Note: For the above assignments analysis of design can be carried out by using simulation software.

- The oral will be based on above term work.

(MFG-22002) Metrology and Quality Control

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to

1. Identify different measurement systems and common types of errors.
2. Introduce and use different types of linear and angular measurement processes and instruments.
3. Gain knowledge and able to select appropriate techniques of interferometers, comparators and screw and gear measurements.
4. Familiarize with surface roughness measurements, Optical instruments and 3D measurements.
5. Familiarize students about industrial practices to analyze the cause for variation by statistical process control using variable and attribute control charts and sampling techniques.
6. Impart the knowledge about total quality management, reliability and quality assurance system used in modern manufacturing.

Unit 1 **(8 hrs)**

Introduction: Meaning of Metrology, Precision, Accuracy, Methods and Errors in Measurement, Calibration.

Linear Measurement: Standards, Line Standards, End Standard, Wavelength Standard, Classification of Standards, Precision and Non-Precision Measuring instruments and their characteristics, Slip Gauges.

Interferometry: Introduction, Flatness testing by interferometry, NPL Flatness Interferometer.

Study of Measuring Machines, Recent Trends in Engineering Metrology, use of interferometry for length angle and surface roughness measurement.

Angle Measurement: Sine bars, Sine centres, Uses of sine bars, angle gauges, Auto Collimator angle dekkor, Constant deviation prism.

Measurement System Analysis: -Introduction, Influence of temperature, operator skills and the instrument errors etc. on the MSA, Gauge R and R study.

Metrology for Additive manufacturing, laser metrology and measurement

Unit 2 **(8 hrs)**

Limits, Fits and Tolerances: Meaning of Limit, Fits and Tolerance, Cost – Tolerance relationship, concept of Interchangeability, Indian Standard System.

Design of limits Gauges: Types, Uses, Taylor's Principle, Design of Limit Gauges, Three surface Generation.

Inspection of Geometric parameters: Straightness, Flatness, Parallelism, Concentricity, Squareness, and Circularity.

Comparators: Uses, Types, Advantages and Disadvantages of various types of Comparators.

Measuring Machines: -Theory of Co-ordinate Metrology, Universal Measuring Machines, Co-ordinate Measuring Machines (CMM), different configurations of CMM, Principle, Error involved, calibration, Probing system, automated inspection system.

Unit 3 **(6 hrs)**

Surface Finish Measurement: Surface Texture, Meaning of RMS and CLA values, Roughness Measuring Instruments, Tactile and Non-tactile measuring instruments, difference between waviness and roughness, Grades of Roughness, Specifications, Assessment of surface roughness as per IS, Relationship between surface roughness and Manufacturing Processes.

Screw Thread Metrology: External Screw Thread terminology, Floating Carriage Instruments, Pitch and flank Measurement of External Screw Thread, Application of Tool Maker's Microscope, Use of Profile Projector.

Gear Metrology: Spur Gear Parameters, Gear tooth thickness measurement: Gear tooth vernier calliper, Constant chord method, Span Micrometer.

Unit 4 **(8 hrs)**

Quality Control: Meaning of Quality, Approaches- Deming's Approach, Juran's Approach, Quality of Product, Quality of Service, Cost of Quality, Value of Quality, and Difference between Inspection, Quality Control and Quality Assurance, Role of Quality in Present day environment. Meaning of quality Control, 100% Inspection and Selective Inspection, Statistics in Selective inspection.

Unit 5 **(5 hrs)**

Statistical Quality Control: Interpretation of SPC Charts, benefits for use on shop floor, Control charts- Attribute (P, nP, C, U) and Variable (X bar, R chart and X & R chart), Sampling inspection, OC Curves and Sampling Plan, Process Capability Index (C_p, C_{pk}), Concept, Methods of determining Cp and Cpk.

Unit 6 **(5 hrs)**

Quality Assurance Systems:

Total quality management (T.Q.M): 7 tools of Problem Solving, Like Cause & Effect Diagram, Pareto Analysis etc., Q.F.D., Quality Circles, Kaizen, six sigma, 5S System.

ISO 9001-2000 Series of Standards: History and Evolution of ISO 9000 Series, importance and overview of ISO 9000- 1998 Series standards, structure of ISO 9000-2000 Series standards, clauses of ISO 9000 series standards and their interpretation and implementation, quality system documentation and audit.

ISO 14000: Environmental management concepts, and requirement of ISO 14001, benefits of environmental management Systems.

Textbooks:

- R. K. Jain, A Textbook of Engineering Metrology, Khanna PublicationsPvt. Ltd.18th Edition, 2002.
- S.P. Gupta, Statistical Methods, Danpat Rai and Sons, New Delhi, 2007.

Reference Book:

- John S. Oahland, Total Quality Management, Elsevier Publications, 3rd Edition 2006.

- P. N. Mukerjee, Total Quality Management, Prentice Hall of India Publications, 2nd Edition 2005.
- Amitava Mitra, Fundamental of Quality Control and improvement, Prentice Hall of India Publications, 2nd Edition 2006.
- G.M.S. De Silva, Basic Metrology for ISO 9000 Certification Elsevier Publications, 3rd Edition 2002.
- I.C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai PublicationsPvt. Ltd.6th Edition, 2004.
- A.S.T.M.E., "Handbook of Industrial Metrology", Prentice Hall, ISBN 10: 0070015368, 1968.

(MFG-22003) Tool and Die Design

Teaching Scheme
Lectures: 2 hrs./week
Tutorial: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Understand the basic concepts, importance and functions of Jigs, Fixtures, press tools and moulding dies.
2. Understand the design aspects of Jigs, Fixtures, press tools and moulding dies.
3. Gain proficiency in the development of required tooling.
4. Understand the analytical/theoretical analysis of Jigs, Fixtures.
5. Understand the analytical/theoretical analysis of press tools and moulding dies.
6. Understand the theory of Plastic Moulding process.

Unit 1 **(5 hrs)**

Jigs and Fixtures: Significance and purpose of jigs and fixtures and their functions in the manufacturing processes. Classification of jigs and fixtures such as machining, assembly and inspection fixtures; universal jigs and fixtures; modular jigs and fixtures. Design features of main elements of jigs and fixtures such as locating, clamping and guiding elements and their integration.
Indexing, locking and auxiliary elements. Bodies, bases or frames of jigs and fixtures.

Unit 2 **(8 hrs)**

Basic Types of Press Working Operations and Equipment: General classification and components of Press Tools.
Dies and Punches: Elements of Dies and Punch set. Types of dies – simple, compound, combination and progressive dies and punches of various press working operations such as punching, blanking, drawing, bending, forming, coining, Fine Blanking Burr free blanking etc. Design of Blanking die, Progressive die, Calculations of clearances, centre of pressure,

different forces, press tonnage, strip layout, sheet utilization ratio, methods of reducing forces.

Unit 3 **(6 hrs)**

Drawing and Bending dies: Design of Shallow & Deep drawing die, Calculation of blank size, number of draws, drawing force, press capacity, ironing & ironing force, Types of Bending dies, various methods used to overcome spring back, Calculation of total bend length and calculation of various forces.

Unit 4 **(8 hrs)**

Design of simple dies for forging: Types of Forging, Guidelines for selection of various design factors, parting line, draft, rib-web, Corner & fillet radius, shrinkage & die wear etc., Detailed calculations of stock size, Design of Fullering, edging, types of die inserts.

Unit 5 **(6 hrs)**

Design of Die casting dies: Die Casting processes Hot & Cold Chamber, Metals for die casting, Design considerations in die casting. Types of cores, feeders, inserts, die lubrications & rules, heat transfer consideration, directional solidification, cooling system, feed and flow system and ejection system, interlocks & safety devices, die casting defects and remedies.

Unit 6 **(8 hrs)**

Plastic and Plastic Moulding: Introduction of compression and transfer moulding process, Study of Injection, and blow moulding process and machine specifications, moulding cycle.

Mould Design: Design of simple two plate injection moulds. Design of simple blow moulds for articles like bottles, cans, etc. Study of types of ejectors, gates, runner's, Study of cooling systems and heat transfer consideration. Calculation of no. of cavities, Mould opening force, ejection force etc.

Textbooks:

- Cyril Donaldson, George H. Le Cain, V.C. Goold, "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2000, 3rd Edition.
- Vukota Boljanovic, "Sheet Metal Forming Processes and Die Design", Industrial Press, New York, 2004.

Reference Book:

- Wilson, Fundamentals of Tool Design, A.S.T.M.E., Prentice Hall of India.
- S. K. Basu, S.N. Mukherjee, R. Mishra, Fundamental of Tool Engineering Design, Oxford & IBH Publishing Co. Pvt. Ltd., 1979.
- J. R. Paquin, R. E. Crowley, Die Design Fundamentals, Industrial Press Inc., 2nd Edition,1987.
- Handbook of Die design Handbook, McGraw Hill, 2006.

- P.C. Sharma; A Text Book of Production Engineering, S. Chand and Company Ltd., New Delhi.
- P.N. Rao, Manufacturing Technology, Tata Mcgraw Hill Publishing Co Ltd, 2000.
- M.H.A. Kempster, Introduction to Jigs and Fixture Design, ELBS Edition, 1990.
- R.G.W. Pye, Injection Mould Design, Longmans Publications, 4th Edition,1989.
- A.S. Athalye, Injection Moulding, MultiTech Publishers Co. Mumbai
- Metal Handbook, Vol-II and III, ASME.
- Forging Handbook, ASM, Vol. 5, 9th edition.
- P.H. Joshi, Press Tools Design & Construction, S. Chand & Company Ltd. Delhi, 2nd Edition (Revised), 2008.

(MFG-22004) Industrial Engineering and Management

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Learn basics concepts of productivity and organization theory.
2. Understand the basic concepts of work study.
3. Apply the techniques of work study and improve productivity.
4. Understand the basic principles of industrial management.
5. Understand the need of personnel management and training of workers.
6. Apply various techniques for job analysis and evaluations.

Unit 1 **(5 hrs)**

Introduction: Definition and Role of Industrial Engineering, Contribution of Taylor and Gilbreth, Organization: Concept of organization, characteristics of organization, elements of organization, organizational structure, organization charts; Introduction to types of organization- formal line, military organization, functional organization, line & staff organization; authority and responsibility, span of control, delegation of authority.
Productivity: Definition of productivity, Productivity of materials, land, building, machine and power. Measurement of productivity: factors affecting the productivity.

Unit 2 **(7 hrs)**

Method Study: Method Study Definition, objective and scope of work-study. Human factors in work-study. Method Study : Definition, objective and scope of method study, activity recording and exam aids, Charts to record moments in shop - operation process charts, flow process charts, travel chart, two handed chart and multiple activity charts. Charts to record movement at work place - principles of motion economy, classification of moments, SIMO chart, and micro motion study. Definition and installation of the improved

method, brief concept about synthetic motion studies Numerical), Introduction to Value Engineering and Value Analysis.

Unit 3 **(6 hrs)**

Work Measurements: Definition, objectives and uses; Work measurement techniques. Work sampling - need, confidence levels, sample size determinations, random observation, conducting study with the simple problems. Time study: Definition, time study equipment, selection of job, steps in time study. Breaking jobs into elements, recording information. Rating and standard rating, standard performance, scales of rating, factors affecting rate of working, allowances and standard time determination; Introduction to PMTS and MTM. (Numerical), Introduction to MOST.

Unit 4 **(4 hrs)**

Principles of Management: Functions related to Planning, organizing, staffing, leading and controlling. Henri Fayol's Principles of Management, Division of Work, Authority and Responsibility, Discipline, Unity of Command, Unity of Direction, Subordination of Individual Interest, Remuneration, The Degree of Centralization, Scalar Chain, Order, Equity, employee stability, and Initiative.

Unit 5 **(6 hrs)**

Methods of job evaluations and merit rating: Job evaluation (Job analysis, job description, job specification, job classification, wage determination) Wages, salary, and incentives, Time wage system, Piece wage system, motivation, wage incentive plans Straight piece rate, Straight piece rate with guaranteed min. wage, Taylor's differential piece rate system, Halsey plan, Rowan plan, and Gantt plan. Personnel management, Performance appraisal and merit rating, methods of performance appraisal.

Textbooks:

- Work Study, ILO
- Basu S.K., Sahu K.C and Rajiv B, Industrial Organization and Management –. PHI New Delhi, 2012, ISBN No. 9788120344211.

Reference Book:

- M.S. Sanders and E.J. McCormick, "Human Factors in Engineering Design", VI Edition,
  McGraw Hill.
- R.M. Barnes, "Motion and Time Study", Wiley International, 1980.
- S. Dalela and Sourabh, "Work Study and Ergonomics". Standard Publishers, Latest Edition

(MFG-22005) Product Design and Manufacturing

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Learn basics of product design process and morphology of design.
2. Understand Design for manufacturing and Assembly (DFMA) concepts.
3. Understand optimization tools and ergonomic principles applied on typical product.
4. Understand design as well as concept of value engineering in new product design.
5. Learn about Design for safety, Environment, and Product cost.
6. Aware of different stages of product design.

Unit 1 **(5 hrs)**

Introduction To Product Design: Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design Phases and flowcharting, Role of Allowance Process Capability, and Tolerance in Detailed Design and Assembly, Introduction to creative design, and the cultural design.

Unit 2 **(8 hrs)**

Product Design Practices in Industry: Introduction, Product Strategies Time to Market, Analysis of the Product, The Three S's, Standardization Renard Series (Preferred Numbers), Simplification, The Designer and it's Role, The Designer: Myth and Reality, The Industrial Design Organization Basic Design Considerations, Problems faced by Industrial Designer. Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in Product Design, Functional Design Practice.

Unit 3 **(10 hrs)**

Engineering Materials: Properties & Selection of Materials – I, Selection of Materials – II, Applications of Engineering Material.
Robust Design, Design for X, Product Design for Manual Assembly, DFMA Guidelines, Ergonomics in Product Design
Selection of Processes-I, Selection of Processes-II, Process Capabilities, Design Guidelines for Sand Casting, Design Guidelines for Die Casting Process.
Product Design Guidelines: Compression Molding and Extrusion, Design Guidelines for Extrusion and Injection Molding, Design Guidelines for Sheet Metal Working, Design Guidelines for Machining, Design Guidelines for Powder Metal Processing.
Assembly Processes: Introduction, Adhesive Joining: Guidelines, Design Guidelines for Mechanical Fasteners, Design Guidelines for Welding, Design Guidelines: Brazing and Soldering

Unit 4 **(6 hrs)**

Optimization in Design: Introduction, Siddal's Classification of Design Approaches, Optimization by Differential Calculus, Lagrange Multipliers, Simplex search Method, Geometric Programming, Johnson's Method of Optimum Design.

Unit 5 **(8 hrs)**

Introduction to Safety Engineering, Design for safety, Environment, and Product cost Design for Environment, Design for Environment: Steps, Product Architecture Design for Safety and Reliability. Elements of visual needs, translating customer needs. Cost and Price Structure, Information Need Sources, Estimating Direct and Indirect Costs, Design and Manufacturing Costs, Ways to Model Manufacturing Costs Human Engineering Considerations in Product Design. Introduction, Human being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6 **(8 hrs)**

Value Engineering and Product Design: Introduction, Historical& Perspective, What is Value? Nature and Measurement of Value, Maximum Value, Normal Degree of Value, Importance of Value, The Value Analysis, Job Plan, Creativity, Steps to Problem-solving and Value Analysis, Value Analysis Tests, Value Engineering Idea Generation Cheek-list, Cost Reduction through Value Engineering Case Study on Tap Switch Control Assembly, Material and Process Selection in Value Engineering.

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD) for design.

Textbooks:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rdEdition, 2003

Reference Book:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, *TAC*- 1997.
- Roland Engene Y., Inetoviez, New Product Development: Design & Analysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod & Dewburst P., Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto & Kristini Wood, Product Design Pearson Education 2004

(MFG-22006) Material Forming

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Learn basic concept of different metal forming process and the application of concept to analyse the processes.
2. Learn application of theoretical approach to solve practical problems associated with different material forming processes such as rolling, drawing, forging, and extrusion.
3. Gain an understanding and appreciation of the breadth and depth of the field of material forming.
4. Understand the various basics of formability, working on metals.
5. Learn how to apply various yeild criterions to metal forming problems.
6. Learn about various advanced metal forming processes.

Unit 1 **(8 hrs)**

Introduction of forming processes: Strain hardening Concept of flow stress determination, Theory of plasticity, Yield criteria for ductile materials- Von-mises criteria, Tresca Criteria, flow stress concept. Effect of temperature, strain rate, metallurgical microstructure, chemical composition, and mechanical properties, for Classification of material forming process. Concept of Formability, formability limits and formability diagram.

Unit 2 **(6 hrs)**

Forging: Introduction, classification of forging processes. Forging equipment- Hammers, presses, furnaces etc. construction working capacities and selection of equipment. Basic forging operations such as drawing, fullering edging, blocking etc. wing Forgeability tests, design of forging as a product, Slab Method of Analysis friction in forging. Forging defects and the remedies. New technologies: Liquid metal forging, isothermal forging, No draft forging, P/M forging, Rotary swaging, roll forging, Lubrications in forging.

Unit 3 **(6 hrs)**

Wire and Tube Drawing: Introduction rod and wire drawing machines - construction and working. Preparation of stock for wire drawing. Wire drawing dies, material and design. Patenting heat treatment. Variables in wire drawing, Maximum reduction in wire in one pass, forces required in drawing. Multiple drawing, work hardening, lubrication in wire drawing. Tube drawing: Methods, force calculation, stock penetration. lubrication in tube drawing

Unit 4 **(8 hrs)**

Rolling of Metals: Scope and importance of rolling. Types of Rolling Mills- Construction and working. Roll bite, reduction, elongation and spread. Deformation in rolling and determination forces required. Process variables, redundant deformation. Roll flattening, Roll camber - its effect on rolling process, mill spring. Defects in rolling. Automatic gauge control- Roll pass classification & design. Lubrication in rolling. Sheet Metal Forming, blanking, bending, drawing and deep drawing.

Unit 5 **(6 hrs)**

Extrusion: Types - Direct, reverse, impact, hydrostatic extrusion. Dies for extrusion, stock penetration. Extrusion ratio Force equipment (with and without friction), metal flow in extrusion, defects. Role of friction and lubricants. Manufacture of seam-less tubes.

Unit 6 **(9 hrs)**

Advanced metal forming processes: High velocity forming- principles, comparison of high velocity and conventional Forming processes. Explosive forming, Magnetic pulse forming, Electrohydraulic Forming, Incremental Sheet Forming Micro-forming, Micro-coining, micro-extrusion, Micro-bending Stretch forming, Micro-Incremental Sheet Forming coining embossing, curling spinning, flow forming advantages, limitations, and application of the process, Joint "extrusion-rolling" process, slitting rolling, surface flexible rolling, flow forming, forming of composite materials.

Textbooks:

- Dieter, Mechanical Metallurgy, ISBN0071004068
- P.N. Rao, "Manufacturing Technology", Tata Mc-GrawHill ISBN0070087695
- S.K. Hajra Choudhary and S.K. Bose, "Elements of workshop Technology" Volume I, II, Asia Publishing House, 10th Edition 2000.

Reference Book:

- Chapman W.A.J, "Workshop Technology", Volume I, II, III, CBS Publishers and k distributors, 5th Edition,2002.
- Degarmo, Black and Kohser, "Materials and processes in Manufacturing", Prentice Hall of India. 2nd Edition, 1998.
- O.P. Khanna and M. Lal, "Production Technology", Vol. I,II, Dhanpat Rai Publication, 5th Edition, 1999.
- B.S. Raghuwanshi, "Workshop Technology", Dhanpatrai Publication, 9th Edition, 1999.
- G.W. Rowe, "Principles of industrial metal working process", Edward Arnold ISBN8123904282.
- Dr. R. Narayanswamy, Metal Forming Technology, Ahuja Book Co. ISBN8176190020
- ASM Metal handbook Vol: 14 Forming and Forging.

(MFG-22007) Kinematics and Dynamics of Machines

Teaching Scheme
Lectures: 2 hrs./week
Tutorial: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Analyse the load-carrying members to be safe under their particular expected loading patterns commonly encountered by machine parts.
2. To select the type of follower motion for particular application.
3. Analyse the stresses on the on different types of gear teeth considering various factors and design the gear pair to be safe under bending and pitting conditions.
4. Select the appropriate type of bearing for a given application, considering static and dynamic loading conditions.
5. Describe journal bearing system and complete the basic design of such bearings.
6. Perform the design and analysis of at least five types of clutches and brakes to specify the required capacity to drive the given system reliably.

Unit 1 **(6 hrs)**
Cams and Follower: Introduction, Types of cam and Follower, Types and Analysis of motion, Uniform velocity, Simple harmonic motion, Uniform acceleration and retardation (Equal and unequal), and Cycloidal motion. Constructions of displacement, velocity and acceleration diagrams and cam profile for given follower motion.

Unit 2 **(6 hrs)**
Design for fluctuating loads: Types of loads Elementary equations for stresses, stress concentration causes and remedies, Fluctuating stresses, S-N Diagram, Endurance limit, Factors affecting Endurance Strength, Design for Finite and Infinite life under reverse stresses, Cumulative damage, Soderberg‘s and Goodman‘s Diagram, Modified Goodman‘s Diagram, Design under combined stresses. Design of components like shaft, bolted joints, springs etc. subjected to variable loading.

Unit 3 **(10 hrs)**
Spur Gears: Classification, Terminology, Law of Gearing, Velocity of sliding, Interference, Minimum number of teeth to avoid interference, Standard system of Gear tooth, Design of Spur Gears, Selection of Type of Gears, Force Analysis, Gear tooth Failures, Selection of Materials, Beam Strength, Wear Strength, Effective Load Calculation, Dynamic Load, Gear Design for Maximum Power Transmitting Capacity.

Helical Gears: Virtual Number of Teeth, Force Analysis, Beam Strength, Wear Strength, Effective Load, Helical Gear Design.

Unit 4 **(7 hrs)**
Bevel Gears: Force Analysis, Design Calculations of Bevel Gears, Beam Strength, Wear Strength, Effective Load.
Worm Gears: Force Analysis, Friction in Worm Gears, Strength Rating of Worm Gears, Wear Rating of Worm Gears, Heat Dissipation.

Flywheel: Introduction, Design Parameters, Energy Storage Capacity of the Flywheel, Weight of the Flywheel, Engine Flywheels, Flywheels for Punches, Stresses in Flywheel Rims, Design of Rimed Flywheel, Stresses in Arms, Design of Arms, Construction of Flywheel.

Unit 5 **(6 hrs)**

Friction Clutches, Brakes and Dynamometer: Pivot collar friction, design consideration for plate, cone & centrifugal clutches. Design of various brakes, like band brake, shoe brake, band & block brake, Disc Brakes, thermal considerations.

Unit 6 **(7 hrs)**

Rolling Contact Bearings: Selection of bearing from Manufacturer's Catalogue, Design for variable loads and Speeds, Bearings with Probability of Survival other than 90%.

Sliding Contact Bearings: Hydrostatic Step Bearing, Energy Losses in Hydrostatic Step Bearing, Reynold's Equation, Raimondi and Boyd Method, Bearing Design – Selection of Parameters, Sommerfeld Number, Constructional Details of Bearings, Temperature Rise.

Textbooks:

- V.B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007.
- S. S. Rattan, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007.

Reference Book:

- R.S. Khurmi J. K. Gupta, "Theory of Machines"‖, Eurasia Publishing House (Pvt.) Ltd, 2nd Edition .
- R.S. Khurmi J. K. Gupta, "A Text book of Machine Design", S. Chand Publication, 25th Edition , 2020.
- Joseph E. Shigley, John J. Uicker, "Theory of Machines and Mechanisms"‖, Oxford University Press, 3rd Edition.
- Thomas Bevan, "Theory of Machines"‖, CBS Publishers and Distributors, 3rd Edition.
- Robert L. Norton, "Design of Machinery"‖, McGraw Hill Higher Education, 3rd Edition.
- Robert L. Mott, P.E, "Machine elements in mechanical design", Pearson Prentice Hall Publication 4th Edition.
- S. S. Rao, "Mechanical Vibrations"‖, Dorling Kindersley (India) Pvt. Ltd., 4th Edition.

(MFG-22008) Process Planning and Tool Selection Lab

Teaching Scheme
Practical: 2 hrs./week
Tutorial: 1 hrs./week

Examination Scheme
Term work - 50 Marks
Practical – 50 marks

Course Outcomes:

At the end of the laboratory work, students will demonstrate the ability to

1. Analyse the dimensions, tolerances, and control of various features of parts.
2. Select and assign sequence of machining processes from basic to principal processes.

3. Identify and select the appropriate tools and toolings for major machining operations to be performed on workpiece.
4. Prepare process plan and flow diagram for given component.

List of Experiments:

The term work shall consist of record of any Six assignments on following topics:

1. Preliminary part print analysis for given components which includes study of part, its dimensions and tolerances and control of its features of parts.
2. Preparation of tolerance chart for any two components also students must describe handling, basic processes for manufacturing, sequence of operations. Study of Special processes, if necessary, related surfaces to be machined, Assembly Process if any for the given parts.
3. Analysis of Part Dimensions of given component: Shape of part as flatness, straightness, roundness, geometrical shapes, symmetry, job requirement of finish on part.
4. Drawing of arrangement of locators, for standard shaped components like rectangular prism, pyramids, cylinder, tube, cones and any one nonstandard component for good geometric control Manufacturing Processes.
5. Identification and list our sequence of various manufacturing processes to be performed on a given component/works-piece, from a drawing such as Basic Processes, Principal Processes, Major Operations and Auxiliary Processes, Supporting Operations.
6. Study and Selection of Tooling: Standard and Special Tooling. Use of Jigs and Fixtures, Selection of Equipment, Tooling. Economics of Tooling.
7. Study of conventional tooling methods for commonly Machined Surfaces, Tooling ideas for Typical features on a job. Multi tooling setups, new tools and tooling methods
8. Study of the machined parts and initial data required for process design from the point of manufacture:
   a. Planning the sequence of machining operations along with selection of machining operations along with selection of machine tools, cutting tools, jigs and fixtures, cutting variables as well as fixing in process dimensions and gauging.
   b. Datum features/surfaces and their selection.
   c. Stock preparations and blank selection with material estimate.
   d. Time estimate and time standards.
   e. Process sheet design for the complete manufacture of the machined parts

(MFG-22009) Metrology and Quality Control Lab

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Term work - 50 Marks
Practical – 50 marks

Course Outcomes:
At the end of the laboratory work, students will demonstrate the ability to

1. Understand principle, construction and working of various measuring instruments,
2. Selection of proper instruments for measurement
3. Calculation of least count of instrument, take reading using the instrument
4. Collection and recording of data and analysis of data

List of Experiments:

1. Determination of Linear/Angular dimensions of a part using Precision and Non-Precision measuring Instruments.
2. Precision angular measurement using a) Sine Bar, b) Auto Collimator, c) Angle Dekkor.
3. Machine Tool alignment tests on any machine tool like Lathe, Drilling Machine or Milling machine (minimum three tests)
4. Measurement of screw thread parameters using Floating Carriage Micrometer.
5. Measurement of Gear parameters: a) Gear Tooth thickness and depth, b) constant Chord, c) Span Measurement, d) Pitch Circle Diameter.
6. Surface Finish measurement using suitable instrument.
7. Interferometry: Measurement of surface flatness using optical flat.
8. Study and Measurement of parameters using Profile Projector.
9. Exercise on Design of Limit Gauges using Taylor's Principles.
10. Study and Measurement of parameters using Tool Makers Microscope.

Interdisciplinary Foundation Course III
[MFG(IF)-22001] Fundamentals of Robotics

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Define basic terms, classify, and analyse the robot structure & gripper designs.
2. Select the drive system with feedback control and sensors.
3. Apply the knowledge of kinematics for link transformation.
4. Write a program for robotic application.
5. Analyze the trajectory planning of joints of robot manipulator.
6. Select the robots on the basis of application areas and perform economic analysis.

Unit 1 **(8 Hrs)**

Basic Concepts in Robotics: Automation and robotics, robot anatomy, basic structure of robots, resolution, accuracy and repeatability. Classification and Structure of Robotics System: Point to point and continuous path systems. Control loops of robotic system,

manipulators, wrist motions and grippers. Robot End Effectors / Grippers: Grippers and tools, Types of end effectors-mechanical, magnetic and vacuum, gripper force analysis and gripper design considerations.

Unit 2 **(8 Hrs)**

Drives and Control Systems: Basic control systems, concepts and models, types of drive system- Hydraulic systems, pneumatic and electrical, DC servo motors, control system analysis, robot activation and feedback components, types of controllers- P, PI, PID controllers.

Sensors in Robotics

Sensors, internal-external sensors, contact and non-contact sensors, position and velocity sensors, Touch and slip sensors, Force and torque sensors, tactile sensors, Proximity, and range sensors. Vision Systems: Vision equipment, line scan and area scan sensor, Charge Coupled Device.

Unit 3 **(8 Hrs)**

Robot Arm Kinematics: Homogenous coordinates and homogenous transformations, Forward and Inverse kinematics in robot, Denavit Hartenberg convention and its applications, Robot dynamics control.

Unit 4 **(6 Hrs)**

Robot Programming: Methods of robot programming, lead through programming methods, a robot program for generating a path in space, motion interpolation, WAIT, SIGNAL and DELAY commands, branching capabilities and limitations of lead through methods. Robot Language: The textual robot languages, generations of robot programming languages, variables, motion commands, end effectors and sensor commands, computations and operations, Introduction to artificial intelligence.

Unit 5 **(6 Hrs)**

Trajectory Planning: Introduction, Joint Space Scheme, Cubic Polynomials with via points, Blending scheme.

Unit 6 **(6 Hrs)**

Robot Applications in Manufacturing: Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots.

Introduction to Telechirs & Futuristic Topics in Robotics: Telechiric machines and its application - handling radioactive materials, work in space mining& under sea operations, Telechiric surgery, collaborative robotics, calibration.

Textbooks:

- S. R. Deb.: Robotics Technology and Flexible Automation, Tata Mc Graw Hill Publishing Co. Ltd.
- P.A. Janakiraman, Robotics and Image Processing, Tata Mcgraw Hill, 1995

Reference Book:

- Yoren Koren: Robotics for Engineers, McGraw Hill Book Co., ISBN 0-07-035341-7.
- M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, : Industrial Robotics Technology, ISBN 0- 07-100442-4.

- K. S. Fu, C. G. S. Lee, R. C. Gonzaler, Robotics Control, Sensing, Vision and Intelligence, Tata McGraw Hill. 2008, ISBN 13: 9780070226258Forging Handbook, ASM, Vol. 5, 9th edition.
- P.H. Joshi, Press Tools Design & Construction, S. Chand & Company Ltd. Delhi, 2nd Edition

Semester VI

(MA-21001) Probability and Statistics for Engineers

Teaching Scheme
Lectures: 2 hrs./week
Tutorial: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Use methods of summarizing and visualizing data sets, compute probabilities of events.
2. Use the concepts of random variables and associated probability distributions, understand the meaning of central limit theorem.
3. Do basic statistical inference (t-test, z-test, F-test, χ^2 –test, confidence interval).
4. Do basic regression analysis.
5. Demonstrate use of R software for all the above.
6. Identify and apply the basic knowledge of statistics for solving real world problems

Unit 1 **(5 Hrs)**
Descriptive statistics: Measures of location and variation. Visualization of data: Frequency tables, bar diagrams, histograms, heat maps, other visualization tools. Review on introduction to combinatorics and probability theory

Unit 2 **(5 Hrs)**
Some of the basic probability distributions: Binomial, Poisson, Exponential, and Normal. Central limit theorem.

Unit 3 **(4 Hrs)**
Introduction to 'R': Introductory R language fundamentals and basic syntax, major Rdata structures, Using R to perform data analysis, creating visualizations using R.

Unit 4 **(6 Hrs)**
Basic statistical inference and hypothesis testing: Estimation, basic tests such as t-test, z-test, F-test, χ^2 -test.

Unit 5 **(4 Hrs)**
Regression methods: Simple linear regression and multiple regression.

Unit 6 **(4 Hrs)**
Engineering applications of statistics: Discussion on reliability and quality control. Introduction to random processes, stochastic processes, Markov chains.

Textbooks:

- Ronald E, Walpole, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists (8th Edition), Pearson Prentice Hall, 2007.
- Ross S.M., Introduction to probability and statistics for Engineers and Scientists (8th Edition), Elsevier Academic press, 2014.

Reference Book:

- S. P. Gupta, Statistical Methods, S. Chand & Sons, 37th revised edition, 2008.
- Morrison S.J., Statistics for Engineers - An introduction, Latest edition, 2009.
- William W. Hines, Douglas C. Montgomery, David M. Goldsman, Probability and Statistics for Engineering, (4th Edition), Wiley Student edition, 2006.
- Kishor S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications (2nd Edition), Wiley Student edition, 2008.
- Stephens L.J., Schaum's outline of statistics for Engineers, Latest edition, 2019.
- The practice of Business Statistics by Manish Sharma and Amit Gupta, Khanna Publishing Company Private Limited, New Delhi, 2014.

(ML-21001) Constitution of India

Teaching Scheme
Lectures: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Comprehend how India has come up with a constitution which is the combination of the positive aspects of other Constitutions.
2. Interpret the Preamble and know the basics of governance of our nation.
3. Identify the different aspects covered under the different important Articles.
4. Apprehend the basic law, its interpretation, and the important amendments.
5. Understand our Union and State Executive better.
6. Recognize the basic that along with enjoying the rights one needs to fulfil one's duties.

Unit 1 **(2 hrs)**
Understanding the concept 'Rule of Law' Meaning and history of Constitution. Understanding the concept of Human Rights and Fundamental Rights.

Unit 2 **(3 hrs)**
Introduction to The Constitution of India, understanding its objects. Preamble to the constitution of India.

Unit 3 **(2 hrs)**
Fundamental rights under Part – III, exercise of the Rights, limitations, and important cases.

Unit 4 **(2 hrs)**

Fundamental duties & their significance. Relevance of Directive principles of State Policy

Unit 5 **(2 hrs)**

Legislative, Executive & Judiciary (Union and State) Prerogative Writs.

Unit 6 **(2 hrs)**

Constitutional Provisions for Scheduled Castes, Scheduled Tribes, & Backward classes. Constitutional Provisions for Women & Children

Unit 7 **(2 hrs)**

Emergency Provisions. Electoral procedure in India, Amendment procedure and few important Constitutional Amendments

Textbooks:

- Introduction to the Constitution of India by Durga Das Basu (Students Ed.) Prentice – Hall EEE, 19th/20th Ed.
- Engineering Ethics by Charles E. Haries, Michael. S. Pritchard and Michael J. Robins Thompson Asia.

Reference Book:

- An Introduction to Constitution of India by M.V. Pylee, Vikas Publishing

(HS-21001) Entrepreneurship Principles and Process

Teaching Scheme
Lectures: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Discover, develop, and assess different types of Entrepreneurial ventures and opportunities.
2. Learn about opportunity and risk analysis.
3. Use the strategies for valuing your own company, and how venture capitalist and angel investors use valuations in negotiating milestones, influence, and control.
4. Pick correct marketing mix and how to position the company in the market by using analytical tools.
5. Learn how to sale themselves and the product/service and to handle objections.
6. Know how organizations operates, their process matrices, start new ventures, write winning business plans.

Unit 1 **(2 hrs)**

Market Research: Introduction to Entrepreneurship, Profile of the Entrepreneur, Market Gap /Opportunity Analysis, Market Research Methods, Defining the Focal Market: Market Segmentation, Industry analysing– Research /Competitive Analysis.

Unit 2 **(2 hrs)**

Types of Companies and Organizations: Company/ Organization Types, Legal Aspects, Taxation, Government Liaison, Building the Team, Mergers and Acquisitions.

Unit 3 **(2 hrs)**

Business Finance: Shares and Stakes, Valuation, Finance Creation (Investors/Financers), Revenue Plans and Projections, Financial Ratios, Business Lifecycle, Break Even.

Unit 4 **(2 hrs)**

Marketing & Digital Marketing: Marketing Basics, Marketing Strategy and Brand Positioning, Plans and Execution Techniques, Marketing Analytics, Online Marketing.

Unit 5 **(2 hrs)**

Sales: Understanding Sales, Pitching Techniques, Sales strategies, Inside Sales v/s Outside Sales, RFP.

Unit 6 **(1 hrs)**

Operations Management: Operational Basics, Process Analysis, Productivity, Quality.

Unit 7 **(3 hrs)**

Start-ups: Start-up Basics, Terms, Start-up Financing, Start-up Incubation, Start-up Incubation, Getting Listed.

Textbooks:

- The Startup Playbook: Secrets of the Fastest-Growing Startups From Their Founding Entrepreneurs by David Kidder.
- Creativity, Inc.: Overcoming the Unseen Forces That Stand in the Way of True Inspiration by Ed Catmull.
- True North by Bill George and Peter Sims.
- Bhargava, S.(2003).Transformational leadership: Value based management for Indian Organizations(Ed.). New Delhi: Response-Sage.
- Cardullo, M.W.P.E. (1999). Technological entrepreneurism: Enterprise formation, financing, and growyh. England: Research Studies Press Ltd.
- Hisrich, R.D. & Peters, M.P. (2001). Entrepreneurship: Starting, developing, and managing an ewenterprise (5thEd.). New York: McGraw-Hill.

Reference Book:

- Kanungo, R.N. (1998). Entrepreneurship and innovation: Models for development (Ed.,Vol.2). New Delhi: Sage.
- Mc Cleland, D.C. (1961). Achieving society. Princeton.
- Van Nostrand. Verma, J.C., & Singh G.(2002).Small business and industry: A hand book for entrepreneurs. New Delhi: Response-Sage.

- Richard A Brealy & Steward C Myres, Principles of Corporate Finance, McGraw-Hill's, 7thEdn,2004.
- Prasanna Chandra, Financial Management: Theory and Practice, Tata McGraw-Hill's, 6thEd, 2004.
- I.M. Pandey, Financial Management, Vikas Publishing.

(MFG-22010) Mini Project

Teaching Scheme
Practical: 4 hrs./week

Examination Scheme
Term work - 50 Marks
Practical – 50 marks

Course Outcomes:
At the end of the laboratory work, students will demonstrate the ability to

1. Acquire knowledge within the chosen area of technology for project development.
2. Get hands on experience on, troubleshooting, maintenance, fabrication, innovation, record keeping, documentation etc thereby enhancing the skill and competency part of technical education.
3. Identify, discuss and justify the technical aspects of the chosen project with a comprehensive and systematic approach.
4. Apply theoretical knowledge of Manufacturing engineering to conceptualize the new product or process.
5. Create the new product or process keeping in mind the needs of society, industry etc.
6. Promote the concept of entrepreneurship.

Guidelines for Mini Project:
The mini project will consist of design, simulation and prototype fabrication of any device which can attempt to address technological solution to the existing problems based on the societal and/or research needs, identified in consultation with faculty mentor/supervisor. Students are expected to carry out feasibility study on the concept finalized. The expected prototype must consist of design of the system using any one of CAD tools, simulation/analysis of predicted behavior / expected outcome and fabrication of functional prototype utilizing various prototype fabrication techniques, such as 3D printing, digital fabrication processes and conventional metal fabrication. It is desirable that the prototype should consists of three systems, mechanical structure, embedded electronics (control system for motors, sensors etc. or as per application) and programming of control systems.

- Students shall form a group of 3 to 5 students, while forming a group shall not be allowed less than three or more than five students.
- Students should do survey and identify needs, which shall be converted into problem statement in consultation with faculty supervisor.
- Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.

- A logbook to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty may give inputs during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert best solution into functional prototype which includes design, simulation and prototype fabrication using 3D printing, digital fabrication processes and conventional metal fabrication.
- The solution to be validated with proper justification and report to be compiled in standard format decided by the department.
- The progress of Mini-Project to be evaluated on continuous basis, minimum two reviews in each semester. Final viva-voce examination based on project should carried out by external examiner along with faculty supervisor/guide.

(MFG-22011) Robotics and Intelligent Manufacturing

Teaching Scheme
Lectures: 2 hrs./week
Tutorial: 1 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Define basic terms, classify and analyze the robot structure & gripper designs.
2. Select the drive system with feedback control and sensors.
3. Apply the knowledge of kinematics for link transformation.
4. Write a program for robotic application.
5. Analyze the trajectory planning of joints of robot manipulator.
6. Select the robots on the basis of application areas and perform economic analysis.

Unit 1 **(8 Hrs)**

Basic Concepts in Robotics: Automation and robotics, robot anatomy, basic structure of robots, resolution, accuracy and repeatability. Classification and Structure of Robotics System: Point to point and continuous path systems. Control loops of robotic system, manipulators, wrist motions and grippers.
Robot End Effectors / Grippers: Grippers and tools, Types of end effectors-mechanical, magnetic and vacuum, gripper force analysis and gripper design considerations.

Unit 2 **(8 Hrs)**

Drives and Control Systems: Basic control systems, concepts and models, types of drive system- Hydraulic systems, pneumatic and electrical, DC servo motors, control system analysis, robot activation and feedback components, types of controllers- P, PI, PID controllers.

Sensors in Robotics: Sensors, internal-external sensors, contact and non-contact sensors, position and velocity sensors, Touch and slip sensors, Force and torque sensors, tactile sensors, Proximity, and range sensors. Vision Systems: Vision equipment, line scan and area scan sensor, Charge Coupled Device, image processing, and analysis, preprocessing, segmentation, and feature recognition, smoothening of binary image.

Unit 3 **(8 Hrs)**

Robot Arm Kinematics and Dynamics: Homogenous coordinates and homogenous transformations, Forward and Inverse kinematics in robot, Denavit Hartenberg convention and its applications Lagrange-Euler formation, Robot dynamics control.

Unit 4 **(6 Hrs)**

Interfacing: Interfacing robot with PC: Robot Programming: Methods of robot programming, lead through programming methods, a robot program for generating a path in space, motion interpolation, WAIT, SIGNAL and DELAY commands, branching capabilities and limitations of lead through methods. Robot Language: The textual robot languages, generations of robot programming languages, variables, motion commands, end effectors and sensor commands, computations and operations, Introduction to artificial intelligence.

Unit 5 **(6 Hrs)**

Trajectory Planning: Introduction, Joint Space Scheme, Cubic Polynomials with via points, Blending scheme.

Unit 6 **(6 Hrs)**

Robot Applications in Manufacturing: Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots.

Introduction to Telechirs & Futuristic Topics in Robotics: Telechiric machines and its application - handling radioactive materials, work in space mining& under sea operations, Telechiric surgery, collaborative robotics, calibration.

Textbooks:

- S. R. Deb.: Robotics Technology and Flexible Automation, Tata Mc Graw Hill Publishing Co. Ltd.
- P.A. Janakiraman, Robotics and Image Processing, Tata Mcgraw Hill, 1995.

Reference Book:

- Yoren Koren: Robotics for Engineers, McGraw Hill Book Co., ISBN 0-07-035341-7.
- M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, : Industrial Robotics Technology, ISBN 0- 07-100442-4.
- K. S. Fu, C. G. S. Lee, R. C. Gonzaler, Robotics Control, Sensing, Vision and Intelligence, Tata McGraw Hill. 2008, ISBN 13: 9780070226258Forging Handbook, ASM, Vol. 5, 9th edition.
- P.H. Joshi, Press Tools Design & Construction, S. Chand & Company Ltd. Delhi, 2nd Edition

(MFG-220212) Operations Research

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Understand the mathematical modelling of real - life optimization problems.
2. Identify the model to be applied for optimization.
3. Formulate and solve optimization problem.
4. Identify the use of simulation techniques and apply simulation techniques.
5. Implement Project Management techniques in real life situations
6. Solve problems related to replacement and project scheduling

Unit 1 **(6 hrs)**

Introduction: Operations Research: Development, history, definitions, objectives, characteristics, limitations, phases, and applications. Optimization models and their classifications.

Linear Programming: Formulation of LP problem, Simplex method (minimization / maximization cases). Degeneracy in LP, Duality in LP, Sensitivity analysis.

Unit 2 **(6 hrs)**

Transportation: Introduction. Methods for finding initial solution. Test of optimality Maximization Transportation problem. Tran-shipment problem. Degeneracy.

Assignment Problem: Introduction. Solution methods. Variations of the assignment problem. Traveling Salesman Problem.

Unit 3 **(7 hrs)**

Sequencing Models: Scheduling and sequencing. Assumptions in sequencing models. Processing "n" jobs on "m" machines. Graphical Method.

Scheduling: Multiple jobs single machine sequencing methods- FCFS, EDD, LFT, etc.

Inventory Control System (Quantitative Approach): Introduction. Meaning of Inventory Control. Functional classifications of Inventories. Advantages of Inventory Control. Deterministic Inventory Models: economic lot size with instantaneous replenishment with and without shortage costs, economic lot size models with quantity discount.

Unit 4 **(7 hrs)**

Queuing Theory: Queuing Systems: Introduction, cost associated with, Classification of queuing models. Kendall's notations. Models: {(M/M/1): (α / FSFS)}. Single server models.

Simulation: Introduction to discrete event Simulation. Monte -Carlo Simulation. Problems related to Monte-Carlo Simulation.
Dynamic Programming: Distinguishing characteristics of D.P. Deterministic DP problems.

Unit 5 **(7 hrs)**

Replacement Models: Replacement of capital equipment that deteriorates with time, Replacement of items that fail without deteriorating.
Theory of Games: Introduction, two–person zero-sum game. Minimax and Maximin principle. Saddle point. Methods for solving game problems with mixed strategies. Introduction to graphical, and iterative methods for solving game problems.

Unit 6 **(7hrs)**

Network Models: Introduction to PERT / CPM. Concepts and construction of network diagrams. Critical path and project duration, floats, network crashing, optimum project duration and cost, PERT activity, time estimate, probability of completion of a project on before specified time, resource allocation and load smoothening, minimal Spanning tree, shortest route and maximal Flow problems.

Textbooks:

- Gupta P. K. and Hira D. S.: Operations Research, S Chand & Company Ltd.
- Sharma S. D., Kedar Nath: Operations Research, Ram Nath& Co.

Reference Book:

- Sharma J. K.: Mathematical Models in Operations Research, Tata McGraw – Hill Publishing Company Limited.
- Taha H. A.: Operations Research - An Introduction, Prentice Hall of India Pvt. Ltd.
- Wagner H. N.: Principles of Operations Research with applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd.
- R. Panneerselvam: Operations Research, Prentice Hall of India Pvt. Ltd.
- Wiest J. D. & Levy F. K.: Managerial Guide to PERT/CPM, Prentice Hall of India Pvt. Ltd.
- Srinath L.S "PERT & CPM principles & Applications" Affiliate East West Press (P) Ltd., New Delhi, 1975.

(MFG-22013) Manufacturing Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Have an overview of manufacturing, manufacturing operations and automation technologies.
2. Study the definition and elements of mechatronics and automation system.
3. Learn how to apply the principles of mechatronics and automation for the development of productive and efficient manufacturing systems.
4. Study the hydraulic and pneumatic systems employed in manufacturing industry.
5. Study material handling technologies for their identification in automated material control purposes.
6. Learn the integration of automation technologies and material handling technologies into manufacturing systems.

Unit 1 **(8 hrs)**

Overview of Manufacturing: Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics.

Automation, Mechatronics and Control Technologies: Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Microsensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms.

Unit 2 **(8 hrs)**

Material Handling and Identification Technologies: Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Automated Guided Vehicle System (AGVS), Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture.

Manufacturing Systems: Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Mechanical Automation, Automated Assembly Systems, Performance and Economics of Assembly system.

Unit 3 **(6 hrs)**

Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis: Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

Unit 4 **(6 hrs)**

Programmable Automation (Processor): Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly language programming of microcontroller.

Unit 5 **(8 hrs)**

Control System and Controllers: Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions.

Discrete Control: Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC.

Unit 6 **(6 hrs)**

Mechatronic Systems: Control Architectures, Design Strategy and Case Studies Introduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems.

Textbooks:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited.
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGraw Hill.

Reference Book:

- Geoffrey Boothroyd, "Assembly Automation and Product Design", CRC, Taylor & Francis Publishers.
- N. P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGraw Hill.
- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw Hill.
- HMT Ltd. Mechatronics, Tata McGraw-Hill.
- Joji P. Pneumatic Controls, Wiley India.

(MFG-22014) Manufacturing Automation Laboratory

Teaching Scheme
Practical: 2 hrs./week

Examination Scheme
Term work - 50 Marks
Practical – 50 marks

Course Outcomes:

At the end of the laboratory work, students will demonstrate the ability to

1. Study the basic elements of mechatronics and automation system.
2. Understand the principles of mechatronics and automation for the development of productive and efficient manufacturing systems.

3. Study the hydraulic and pneumatic systems employed in manufacturing industry.
4. Study material handling technologies for their identification in automated material control purposes.

List of Experiments:

The term work shall consist of record of any eight assignments on following topics:

1. Study & Design of basic hydraulic and pneumatic circuits: such as Standard ON-OFF and Pneumatic Latch.
2. Study & Design of Pneumatic or Hydraulic circuit for Two Push Button Control and Clamping of Work piece.
3. Study & Design of Pneumatic or Hydraulic circuit for material handling.
4. Study & Experiments in 8051 Microcontroller & its applications in Production Engineering.
5. Study & experiments in Programmable Logic Controllers (PLC).
6. Study of Displacement, Level, Pressure controls.
7. Measurements & Design of circuit for Speed & Temperature measurements.
8. Study & Design of Simple Hydraulic or Pneumatic and Electro-Hydraulic or Electro Pneumatic Automatic Control Circuit Problem.
9. Study & Design of Electro-hydraulic or Electro-pneumatic Control Circuit Problem.
10. Study of Maintenance and Troubleshooting of Fluid Power Systems.

Note: Oral shall be based on above assignments.

Department Elective - I

[MFG(DE)-21001] Supply Chain and Logistics Management

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to

1. Understand, analyse the designing, planning and operational decisions of SCM.
2. Identify, clarify managerial action to improve supply chain performance for the desired goals.
3. Understanding the planning and managing inventory.
4. Understand and apply the performance measurement in supply chain.
5. Applying the management techniques on industrial logistics and supply chains problems.
6. Explain the likely future development of logistics and supply chain management.
7.

Unit 1 **(6 hrs)**

Introduction to Supply chain management

Definition of Supply chain and supply chain management, Supply chain stages and decision phases, process view of a supply chain. Supply chain flows. Internal supply chains and External supply chains. Information systems and SCM, Inventory management across the SC. Drivers of supply chain performance. Competitive and supply chain strategies. Achieving strategic fit**.** Expanding strategic scope, Challenges facing SC managers

Unit 2 **(8 hrs)**

Supply Chain Network

Supply Chain Network (SCN) - Role, Factors, design options for distribution network. Models for Facility Location and Capacity Allocation and problem solving, Impact of uncertainty on SCN - Discounted Cash Flow Analysis.

Unit 3 **(8 hrs)**

Planning & Managing Inventories in a Supply Chain

Role of forecasting in the SC, Time series forecasting methods, Review of inventory concepts. Trade promotions, Managing Cycle Inventory, Cycle time overview, causes of long cycle times, Methods of reducing cycle time, Safety inventory determination.

Unit 4 **(8 hrs)**

Sourcing and Transportation in the supply chain

Role of Sourcing, Supplier - Scoring & Assessment, Selection & Contracts. Design Collaboration. Role of transportation, Factors affecting transportation decisions. Modes of transportation and their performance characteristics. Designing transportation network, Tailored transportation, Routing and scheduling in transportation. International transportation.

Unit 5 **(6 hrs)**

Coordination and Technology in the Supply Chain

Coordination in a supply chain: Bullwhip effect. Obstacles to coordination. Managerial levers to achieve co-ordination, Building strategic partnerships. The role of IT in Supply Chain, The Supply Chain IT Framework, CRM, SRM. The role of E-business in a supply chain, The E-business framework, E-business in Practice. Case discussions.

Unit 6 **(4 hrs)**

Performance measurement and Cases in SCM: Performance metrics in SCM, Balanced scorecard approach.

Textbooks:

- Sunil Chopra & Peter Meindl; Supply Chain Management -Strategy, Planning & Operation; 11 Edition - 2003. Pearson Education Inc.
- Douglas Lanibert & James Stock: Strategic Logistics Management: Irwin McGraw Hill.

- Robert B. Handfield, Ernest L. Nichols, Jr, Introduction to Supply chain management, Prentice Hall.

Reference Book:

- Robert B. Handfield, Ernest L. Nichols, Jr.; Supply Chain Redesign-Transforming Supply Chains into Integrated Value Systems 2002, Pearson Education Inc., ISBN:8129701138.
- Jeremy F. Shapiro, Duxbury; Modelling the Supply chain: 2002, Thomson Learning, ISBN: 0-534-37363-
- David Simchi Levi, Philip Kaniinsky& Edith Simchi Levi: Designing and Managing the Supply Chain: McGraw Hill.
- B.S. Sahay, Supply Chain Management: Mc. Millen.

[MFG(DE)-21002] Reliability and Maintenance

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Get acquainted with concept of reliability and maintainability.
2. To analyze a system for reliability assessment and life cycle costing.
3. To understand and get familiarized with condition monitoring in maintainability.
4. To understand the importance and application of reliability.
5. To use the concepts of reliability in designing and maintenance of products.
6. Simulate techno economic life which is very important for industry application.

Unit 1 **(5 hrs)**

Reliability: Definition-methods of improving reliability, derivation of Reliability function, configurations of reliability, series parallel & mixed configuration, simple problems.

Unit 2 **(8 hrs)**

Reliability Calculations: Methods of improving reliability, redundancy element, unit stand-by redundancy, reliability models, constant hazard, simple problems, hazard models.

Unit 3 **(8 hrs)**

Maintenance Systems: Objective, of maintenance, maintainability and availability concepts, types of availability - mean time to failure-mean time between failures-mean time to repair-mean down time- Reliability allocation.

Unit 4 **(8 hrs)**

Life Cycle Costing: Techno economic Life; Reliability effort function, simple cost models for Life cycle.

Unit 5 **(8 hrs)**

Maintenance Management: Principle types of maintenance breakdown, periodic, preventive and total productive maintenance, maintenance planning and control strategies, maintenance planning, maintenance policies, maintenance organization, maintenance standards-quality service standards-maintenance Strategy, influence of Terotechnology on maintenance management maintenance performance indices, maintenance system documentation. Failure Analysis: using causes & effects using Ishikawa diagram FMEA, FMECA.

Unit 6 **(8 hrs)**

Condition Monitoring: Definitions, advantages, limitations, through ferrography and particle analyser, spectroscopic oil analysis programme (SOAP), contaminant analysis, vibration monitoring, use of monitoring, instruments and applications-magnetic chip detector. Role of computers in condition monitoring. Monitoring, systems- layers & monitors.

Textbooks:

- L. S. Srinath Reliability Engineering, -Affiliated East -West press, 2002.
- S.K. Basu & B. Bhadury, Terotechnology: Reliability Eng. & maintenance Management, Asian book Private Ltd., Delhi, 1st Edition, 2003.

Reference Book:

- K. K. Ahuja, Industrial management and Organizational Behaviour, Khanna Publications. 1999.
- H. P. Garg, Industrial Maintenance, S. Chand & company. Ltd, Third Edition 1990.
- Dr. Shankar, Industrial engineering Management Golgotia Publications Pvt. Ltd. 1997.
- A.K. Gupta, Reliability Engineering & Terotechnology.

[MFG(DE)-21003] Facility Planning and Design

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to

1. Learn formulations, models, and analytical procedures for the study of facilities layout planning.
2. Learn fundamental principles of material handling.
3. Understand and apply computer aidded techniques of layout planning.
4. Understand and apply Quantitative Approaches in Facilities Planning.
5. Analyze and apply advanced analytical approaches to industrial facility planning and design problems.
6. Propose an advanced and optimized design of factory layout incorporating product, process, and personnel requirement.

Unit 1 **(6 hrs)**

Plant Location and Layout: Introduction to FPD, objective and scope, Factors influencing plant location, Theories of plantlocation and location economies, categories of plant and their characteristics, advantages, and limitations, different plant layout approaches like Immer, Nadler, Muther, etc.

Unit 2 **(8 hrs)**

Material Handling: Definition, principles, system design and selection of equipment, unit load concepts, basic material handling equipment in industries, material handling system design methodology, equipments mechanization level, automated guided vehicles.

Unit 3 **(6 hrs)**

Computer Aided Layout: CRAFT, COFAD, PLANET, CORELAP, ALDEP, Muther's Classification, line balancing for machine layout, machine cell layout procedures.

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Unit 4 **(8 hrs)**

Space Determination and Area Allocation: Factors for consideration in space planning, receiving, storage, production, shipping, otherauxiliary) service actions, establishing total space requirement, area allocation factor to be considered, expansion, flexibility, aisles column and area allocation procedure. Design of layout using Travel chart, plot plan, block plan, activity relationship score, TCR estimation.

Unit 5 **(8 hrs)**

Quantitative Approaches to Facilities Planning: Facility requirement involving deterministic models, single and multi-facility location models, Location allocation problems, Warehouse layout models, in process inventory requirement, delivery vehicle estimation, warehouse layout model involving numerical, assignment problem for personal deployment.

Unit 6 **(8 hrs)**

Analytical Approaches in FPD: Facility requirement through waiting line models, simulation, repair limit model, spare parts inventory models, software manpower requirement model, optimum inspection policy, corrective maintenance schedule, optimum overhaul frequency, evaluation and selection of facility planning models.

Textbooks:

- Tompkins, J A and White, J. A. Facilities Planning, John Wiley & Sons.
- Francis, R.L. and White, J. A. Facility Layout and Location, John Wiley & Sons.c

Reference Book:

- James M. Apple, Plant Layout and Material handling 2nd Edition., The Ronald Press Company John, Wiely and Sail .
- Muther Richard, Practical Plant Layout, McGraw hill.
- SundereshHeragu, Facilities Design, PWS Publishing Company, ISBN- 0-534- 95183.
- James M Moore, Plant Layout Design, MacMillon Co. 1962 LCCCN: 61 - 5204.

[MFG(DE)-21004] Micro and Nano Manufacturing

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Understand basic concepts of and principles of Micro and nano systems.
2. Impart fundamental knowledge of micro and nano fabrication processes to the students.
3. Impart fundamentals of hybrid micro machining processes
4. Learn about nano finishing processes and its applications
5. Basic nowledge about working principles and applications of micro sensors/micro kactuators.
6. Know the advance applications of micro-nano systems to various critical applications such as biomedical, microfluidics etc

Unit 1 **(6 hrs)**

Fundamental of micro and nano technology: Micro and Nanofabrication, concepts of micro and Nano-systems and Microsystems Products, Microsystems and Microelectronics, Application of Microsystems, Standardisation and Commercialization Issues of Micro-Nano Systems.

Unit 2 **(8 hrs)**

Micro machining: Ultra Sonic Micro Machining, Abrasive Water Jet Micro Machining – Tool based Micro-machining, Chemical and Electro Chemical Micro Machining – Electric Discharge Micro machining. Electron and Laser Beam Micro Machining, Hybrid Micro machining,

Electro Chemical Discharge micro machining, Machining of Micro gear, micro nozzle, micro pins and its applications. Tool based micromachining (TBMM).

Unit 3 **(8 hrs)**

Nano machining and Finishing: Focused Ion Beam Machining –Plasma Beam Machining –electrochemical nanomachining, Abrasive Flow finishing –- Magnetic Float polishing – Elastic Emission Machining – Chemo-Mechanical Polishing, Magnetic Abrasive Finishing – Magneto rheological finishing – Magneto Rheological abrasive flow finishing.

Unit 4 **(7 hrs)**

Concepts of micro forming and welding, Micro extrusion: Micro and Nano structured surface development by Nano plastic forming, Roller Imprinting, Electrochemical and Electro-discharge machining etc, Micro bending and micro welding with LASER, Electron beam for micro welding, Metrology for micro machined components.

Unit 5 **(6 hrs)**

Micro sensors, Micro actuation: MEMS with Micro actuators, Micro actuators with mechanical Inertia – Micro fluidics, micro/nano biosensors: Classification of physical sensors, Integrated, Intelligent or Smart sensors, Bio sensing Principles and sensing methods, Biosensors arrays and Implantable devices, Innovative Applications on Present Devices: Nano chips, Nanotubes and Nanowires, Integration of chips and microprocessors.

Unit 6 **(7 hrs)**

Introduction to different Biomedical Applications of Microsystems: Delivery of Diagnostic and Therapeutic Agents to Vascular Targets, Real-Time Biological Imaging and Detection, Diagnostic and Therapeutic Applications of Metal Nano shells, Micro devices for Oral Drug Delivery etc. Technology Support, Meeting Social Needs, future scope of micro-nano system.

Textbooks:

- Foundations of MEMS, Chang Liu 2006, Prentice Hall.
- Jain V.K., Introduction to Micro machining Narosa Publishing House, 2011

Reference Book:

- Bhattacharyya B., "Electrochemical Micromachining for Nanofabrication, MEMS and Nanotechnology", William Andrew publications (Imprint of Elsevier) 2015.
- Bandyopadhyay. A.K., Nano Materials, New age international publishers, New Delhi, 2008, ISBN: 8122422578.
- Tai-Ran Hsu, "MEMS and MICROSYSTEMS", John Wiley & Sons, New Jersey, 2008.
- Micro fabrication & Nano manufacturing by Mark J. Jackson.
- Bharat Bhushan, Handbook of nanotechnology, springer, Germany, 2010.

- Nanotechnology and Nano electronics – WR Fahrner, Springer International Z. Cui, Nanofabrication, Springer, 2008.
- Stephen.D. Senturia, "Micro-systems design", Springer, 2000.
- Nanotechnology and Nano electronics – WR Fahrner, Springer International Z. Cui, Nanofabrication, Springer, 2008.
- Janocha H., Actuators – Basics and applications, Springer publishers – 2012. Company Ltd., 2000, 3rdEdition.

MFG(DE)-21005] Advanced Joining Technology

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Understand the working of various conventional & advanced Welding Processes.
2. Understand the advantages & limitations of welding processes.
3. Apply the knowledge to select the appropriate welding process based on application, customer requirement and specifications.
4. Understand the Weld Metallurgy of joint.
5. Demonstrate an ability of inspection and testing of welded components and apply remedial measures to minimize defects in welding.
6. Suggest an appropriate measure or method to obtain a defect free weld.

Unit 1 **(7 hrs)**

Gas and Arc welding processes: Fundamental principles – Air Acetylene welding, Oxyacetylene welding, Carbon arc welding, shielded metal arc welding, Submerged arc welding, TIG & MIG welding, Plasma arc welding and Electroslag welding processes - advantages, limitations, and applications.

Unit 2 **(7 hrs)**

Resistance Welding Processes: Spot welding, Seam welding, Projection welding, Resistance Butt welding, Flash Butt welding, Percussion welding and High frequency resistance welding processes - advantages, limitations and applications.

UNIT 3 **(7 hrs)**

Solid State Welding Processes: Cold pressure welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction welding, Forge welding, Roll welding

and Hot pressure welding processes - advantages, limitations and applications, Advances in adhesive bonding, Brazing and soldering, cladding.

UNIT 4 **(9 hrs)**

Advanced Welding Processes: Thermit welding, atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Friction stir welding, Cold Metal Transfer - concepts, processes and applications, Under Water welding, Welding automation in aerospace, nuclear and surface transport vehicles, Automated Welding, Remote Welding, Robotic Welding, Intelligent Systems for Welding Process Automation.

UNIT 5 **(6 hrs)**

Testing and Design of Weldments: Design and quality control of welds. Edge preparation types of joints, weld symbols. Stresses in butt and fillet welds - weld size calculations. Design for fatigue. Destructive and non-destructive testing of weldments. Weldability Testing - tensile, bend hardness. Impact, notch and fatigue tests. Visual examination - liquid penetration test, magnetic particle examination. Radio graphs, ultrasonic testing. Life assessment of weldments. IS codes.

UNIT 6 **(6 hrs)**

Weld Metallurgy: Weld thermal cycles and their effects, concept of weldability and its assessment. Heat affected Zone and its characteristics Weldability of steels, cast iron, stainless steel, aluminium, Mg, Cu, Zirconium, and titanium alloys, Carbon Equivalent of Plain and alloy steels, Hydrogen embrittlement, Lamellar tearing, Residual stress, Distortion and its control. Heat transfer and solidification, Analysis of stresses in welded structures, pre and post welding heat treatments, weld joint design, welding defects.

Textbooks:

- Parmer R.S., "Welding Engineering and Technology", Khanna Publishers, New Delhi, 2008.
- Little R.L., "Welding and Welding Technology", Tata McGraw Hill Publishing Co., Ltd., New Delhi, 34th reprint, 2008.
- Kalpakjian S. "Manufacturing Engineering and Technology" Prentice Hall Pearson Education India; 4th edition, 2002.

Reference Book:

- Schwartz M.M. "Metals Joining Manual". McGraw Hill Books, 1979.
- Tylecote R.F. "The Solid Phase Welding of Metals". Edward Arnold Publishers Ltd. London, 1968.
- AWS- Welding Hand Book. 8th Edition. Vol- 2. "Welding Process"
- Nadkarni S.V. "Modern Arc Welding Technology", 1st edition, Oxford IBH Publishers, 2005.
- Christopher Davis. "Laser Welding- Practical Guide". Jaico Publishing House, 1994.

- Davis A.C., "The Science and Practice of Welding", Cambridge University Press, Cambridge, 1993.
- Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007.

[MFG(DE)-21006] Design of Experiments and Optimization

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Know the basic concepts of and principles of Design of experiments.
2. The course will impart fundamental knowledge of Optimization techniques to the students.
3. Understand importance of optimization of industrial process management.
4. Analyse and appreciate variety of performance measures for various Design of experiments and optimization problems.
5. Apply basic concepts of mathematics to formulate an optimization problem.
6. Solve the optimization problems.

Unit 1 **(11 hrs)**

Introduction: Need for Research, Need for Design of Experiments, Experimental Design Techniques, Applications of Experimental Design in Marketing, Production & Finance. Analysis of Variance: Introduction, Test of Hypothesis & Hypotheses Concerning Mean(s), Two Tailed Test Concerning Difference between Two Means when the Variances of the Populations are Known and are Unknown with Small Sample Sizes, Limitations of Testing of Hypothesis for Difference between the Means of Two Samples, Testing of Hypothesis Using F-Test, F-Distribution, Two Tailed F-Test Concerning Equality of Two Population Variances.

Unit 2 **(8 hrs)**

ANOVA: Need for Analysis of Variance (ANOVA). Simple Designs of ANOVA: Introduction, Completely Randomized Design, Randomized Complete Block Design, Latin Square Design, Duncan's Multiple Range Test, Factorial Design of Experiment, Two-Factor Factorial DOE, Factorial DOE with Three Factors, 2^n Factorial DOE, Concept of 2^2& 2^3 Factorial DOE, Yates' Algorithm for 2^n, 3^n Factorial DOE, Concept of 3^2& 3^3 Factorial DOE, Experimental Designs with at least One Random Factor, Distinction between Random Factor and Fixed Factor, Expected Mean Square (EMS) Rule, Rules (Steps) for Formation of Expected Mean Squares.

Unit 3 **(9 hrs)**

Regression Approach: Introduction, Linear Regression, Simple Regression, Testing of Hypothesis on the Significance of Regression, Multiple Regression, Regression Model with Two Independent Variables Using Normal Equations, Matrix Method for Regression Model (Generalized Method). Response Surface Methodology: Introduction, Types of Design, Response Surface Design with Blocks, CCD, BBD, Mixture Experiments.
Orthogonal Arrays: Introduction, Design of Orthogonal Arrays, Column Effect Method, ANOVA for Orthogonal Array, Determination of Four-level Factor from Two-level Factors,

Determination of Three-level Factor from Two-level Factors, Orthogonal Arrays with Three-level Factors Having Some Interactions, Estimation of Predicted Mean and Confidence Interval for Predicted Mean, Confirmation Experiments.

Unit 4 **(5 hrs)**

Robust Parameter Design: Introduction, Signal-to-Noise Ratio, ANOVA for S/N Ratio, Steps of S/N Ratio Approach, Robust Parameter Design Using Response Surface Methodology. Grey Relational Analysis: Introduction, Steps of Grey Relational Analysis.

Unit 5 **(7 hrs)**

Nonlinear programming: Convex sets and convex functions, their properties, Convex programming problem, Generalized convexity, Pseudo and Quasi convex functions, Invex functions and their properties, KKT conditions.

Unit 6 **(10 hrs)**

Search Techniques: Direct search and gradient methods, Unimodal functions, Fibonacci method, Golden Section method, Method of steepest descent, Newton-Raphson method, Conjugate gradient methods. Dynamic Programming: Deterministic and Probabilistic Dynamic Programming, Discrete and continuous dynamic programming, simple illustrations. Multi-objective Programming: Efficient solutions, Domination cones. Some famous MADM & MCDM Methods.

Advanced optimization techniques: Introduction to some evolutionary algorithm, GA, PSO, TLBO, ABC, JAYA, Simulated Annealing, case studies of optimization & decision making in manufacturing environment

Textbooks:

- R. Pannerselvam, Design and analysis of experiments, PHI Learning.
- Engineering Optimization: Theory and Practice by S.S. Rao; New Age Publishers.

Reference Book:

- D. G. Luenberger, Linear and Nonlinear Programming, Second Edition, Addison Wesley (2003).
- R. Venkata Rao, V.J. Savsani, Mechanical Design Optimization Using Advanced Optimization Techniques (SpringerSeries in Advanced Manufacturing).
- R. E. Steuer, Multi Criteria Optimization, Theory, Computation and Application, John Wiley and Sons, New York (1986).
- Decision Making in the Manufacturing Environment Using Graph Theory and Fuzzy Multiple Attribute Decision Making Methods, Vol. 1 & Vol. 2by R. Venkata Rao; Springer Pub.
- Jaya: An Advanced Optimization Algorithm and its Engineering Applications by Ravipudi Venkata Rao; Springer Pub.
- Teaching Learning Based Optimization Algorithm and Its Engineering Applications by Ravipudi Venkata Rao; Springer Pub.
- Douglas C. Montgomery, Design and Analysis of Experiments.
- Paul Allen, Design of Experiments for 21st Century Engineers.
- Jiju Antony, Design of Experiments for Engineers and Scientists,(Elsevier Insights)

Interdisciplinary Open Course-I

[MFG(IF)-22002] Reliability Engineering

Teaching Scheme
Lectures: 2 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Understand and familiarize with concept of reliability and maintainability.
2. Understand the that how to analyze a system for reliability assessment and life cycle costing.
3. Familiarize with condition monitoring in maintainability.
4. Understand the importance and application of reliability.
5. Use the concepts of reliability in designing and maintenance of products.

Unit 1 **(6 hrs)**
Reliability: Definition -methods of improving reliability, derivation of Reliability function, configurations of reliability, series parallel & mixed configuration, simple problems

Unit 2 **(6 hrs)**
Reliability Calculations: Methods of improving reliability, redundancy element, unit stand-by redundancy, reliability models, constant hazard, simple problems, hazard models.

Unit 3 **(6 hrs)**
Maintenance Systems: Objective, of maintenance, maintainability and availability concepts, types of availability - mean time to failure-mean time between failures-mean time to repair-mean down time- Reliability allocation

Unit 4 **(6 hrs)**
Life Cycle Costing: Techno economic Life; Reliability effort function, simple cost models for Life cycle.

Unit 5 **(4 hrs)**
Maintenance Management: Principles types of maintenance breakdown, periodic, preventive and total productive maintenance etc.

Textbooks:

- L. S. Srinath Reliability Engineering, Fourth Edition Affiliated East -West Press, Reprint 2009.
- S.K. Basu & B.Bhadury, Terotechnology: Reliability Engg& maintenance Management, Asian book Private Ltd., Delhi, 1stEdition, 2003.

Reference Book:

- C. Singh and C.S. Dhillon, Engineering Reliability-New Techniques and Applications –John Wiley and Sons
- K. K. Ahuja, Industrial management and Organizational Behaviour, Khanna Publications. 1999
- H. P. Garg, Industrial Maintenance, S. Chand & company. Ltd, Third Edition 1990.
- Dr. Shankar, Industrial engineering Management Golgotia Publications Pvt. Ltd. 1997
- Dr. A.K. Gupta, Reliability, Maintenance and Safety Engineering, Laxmi Publications

Minors- Manufacturing Technology (Mechanical)
SEMESTER-V
Precision Engineering

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. The meaning precision machining and the importance of it.
2. The requirements of machine network elements to achieve precision in the components.
3. The principles of various precision engineering processes and apply them in actual field.
4. Various method of micromachining using LASER and other processes.
5. To posses basic knowledge related to new trends in manufacturing and its precise control.

Unit 1 **(7 hrs)**

Precision engineering: Introduction – Precision, Accuracy & Smoothness – Need – Development of overall machining precision Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility.

Unit 2 **(7 hrs)**

Precision machine element: Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers – Rolling elements – hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings-Hybrid gas bearings-materials for bearings.

Unit 3 **(7 hrs)**

Error Control: Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control errors due to locations – principle of constant location surfaces.

Unit 4 **(7 hrs)**

Precision Manufacturing: Micro machining processes-diamond machining - micro engraving - Micro replication techniquesforming-casting-injection moulding - micro embossing - Energy assisted processes LBM, EBM, FIB, Micro electro discharge

machining-photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition.

Unit 5 **(7 hrs)**

MEMS: Introduction – MEMS –characteristics- principle – Design – Application: automobile, defence, health care, Industrial, aerospace etc.,

Unit 6 **(7 hrs)**

Micromachining: Laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation. LIGA, S-LIGA 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

Textbooks:

- Venkatesh V.C. and Izman S., —Precision Engineering‖, Tata McGraw Hill, 2007.
- Murthy R.L., —Precision Engineering‖, New Age International, 2009

Reference Book:

- Nakazawa H., —Principles of Precision Engineering‖, Oxford University Press, 1994.
- Institute of Physics Publishing, Bristol and Philadelphia, Bristol, BSI 6BE U.K

Minors- Manufacturing Technology (Mechanical)
SEMESTER –VI
Additive Manufacturing

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Describe the principles of various additive manufacturing technologies to differentiate between conventional manufacturing and AM.
2. Understand the concepts of design for additive manufacturing which will lead to development of .STL file using preprocessing techniques.
3. Understand the concepts of post processing techniques to apply different methods to remove support structures, accuracy and aesthetic improvements.
4. Exposure of additive manufacturing applications from various fields such as automobile, biomedical, food and fashion etc.
5. Understand the methodology to build the 3d printer based on FDM technology.

Unit 1 **(6 hrs)**

Introduction to Additive Manufacturing (AM): Introduction to Additive Manufacturing, History of AM, Distinction between AM and conventional Manufacturing, Advantages and Limitations of AM, AM process chain. Classification of AM processes: Classification of AM Technology based on Variety of Materials Used, Type of Material Used and Techniques used for manufacturing. Study of AM Processes like SLA (Stereolithography), FDM (Fused Deposition Modelling), SLS (Selective LASER Sintering), LOM (Laminated Object Manufacturing) etc.

Unit 2 **(6 hrs)**

Design for AM: Design for manufacturing and Assembly concepts and objectives, AM unique capabilities, Exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/ numbers etc.

Unit 3 **(6 hrs)**

Preprocessing for AM: Conceptualization, Data Generation for AM through CAD and Reverse Engineering, conversion to STL, , STL file manipulation and errors in STL File, Transfer of Data to AM Machines

Unit 4 **(6 hrs)**

Post Processing for AM: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

Unit 5 **(6 hrs)**

Applications of Additive Manufacturing Technology Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling, new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries

Unit 6 **(6 hrs)**

Construction FDM Technology 3D Printer Construction of CNC machines and its movements, Similarity between CNC machine and RP Machine, Mechanical hardware, Electronics circuitry and Software integration used in FDM technology and its purpose, Assembly and Construction of 3D Printing FDM Machine.

Textbooks:

- Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World scientific, 2003.
- Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010

Reference Book:

- Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.
- D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001.

Minors- Manufacturing Technology (Mechanical)
SEMESTER-VII
Manufacturing Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. To have an overview of manufacturing, manufacturing operations and automation technologies
2. To study the definition and elements of Mechatronics and automation system
3. To learn how to apply the principles of Mechatronics and automation for the development of productive and efficient manufacturing systems.
4. To study the hydraulic and pneumatic systems employed in manufacturing industry.
5. To study material handling technologies for their identification in automated material control purposes.
6. To learn the integration of automation technologies and material handling technologies into manufacturing systems.

Unit 1 **(5 hrs)**

Overview of Manufacturing: Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics.

Automation, Mechatronics and Control Technologies:Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Microsensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

Unit 2 **(8 hrs)**

Material Handling and Identification Technologies: Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Automated Guided Vehicle System (AGVS), Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture

Manufacturing Systems: Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems

Unit 3 **(6 hrs)**

Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis: Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional

Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

Unit 4 **(6 hrs)**

Programmable Automation (Processor): Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly language programming of microcontroller

Unit 5 **(8 hrs)**

Control System and Controllers: Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions

Discrete Control: Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC

Unit 6 **(6 hrs)**

Mechatronic Systems: Control Architectures, Design Strategy and Case StudiesIntroduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems

Textbooks:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGrawHill

Reference Book:

- N. P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGraw Hill
- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw Hill
- HMT Ltd. Mechatronics, Tata McGraw-Hill
- Joji P. Pneumatic Controls, Wiley India

Minors- Manufacturing Technology (Mechanical)
SEMESTER-VIII
Industrial Design of Products

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Students learn basics of product design process and morphology of design.
2. Students are exposed to Concept design, detail design, manufacturing, marketing, Introduction strategy of new product.
3. Students learn about process of design for production of metal components.
4. To understand optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
5. To understand all phases of product. Concept to final manufacturing

Unit 1 **(5 hrs)**

Introduction To Product Design: Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design Phases and flowcharting, Role of Allowance Process Capability, and. Tolerance in Detailed Design and Assembly.

Unit 2 **(8 hrs)**

Product Design Practice And Industry: Introduction, Product Strategies Time to Market, Analysis of the Product, The Three S's, Standardization Renard Series (Preferred Numbers), Simplification, The Designer and their Role, The Designer: Myth and Reality, The Industrial Design Organization Basic Design Considerations, Problems faced by Industrial Designer. Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in Product Design, Functional Design Practice. Review of Strength, Stiffness and Rigidity Considerations in Product Design Principal Stress Trajectories (Force - Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience, Designing for Uniform Strength, Tension vis-à-vis Compression.

Unit 3 **(8 hrs)**

Design for Production -Metal Parts: Producibility Requirements in the Design of Machine Components, Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, The Role of Process Engineer, Ease of Location and Clamping, Some Additional Aspects of Production Design, Die Casting and Special Castings, Design for Powder Metallurgical Parts, Expanded Metals and Wire Forms.

Designing with Plastics, Rubber, Ceramics and Wood: Approach to Design with Plastics, Plastic Bush Bearings, Gears in Plastic, Fasteners in Plastic,Rubber Parts, Design

Recommendations for Rubber Parts, Distortion in Rubber, DimensionalEffects, Tolerances, Ceramics and Glass Parts, Production Design Factors for Ceramic Parts,Special Considerations for Design of Glass Parts, Dimensional Factors and Tolerances, Wood.Design for assembly and disassembly.

Unit 4 **(8 hrs)**

Rapid Prototyping: Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereo lithography etc.), Typical Process Chain forRP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit 5 **(8 hrs)**

Economic Factors Influencing Design: Product Value, value analysis, design for Safety, Reliability and Environmental Considerations, Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).

Human Engineering Considerations in Product Design: Introduction, Human being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6 **(6 hrs)**

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD) for design, product design optimization methods

Textbooks:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rd Edition, 2003

Reference Book:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, TAC-1997.
- Roland EngeneY.,Inetoviez, New Product Development: Design &nalysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod & DewburstP.,Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto and Kristini Wood, Product Design Pearson Education 2004.
- Venuvinod, PK., MA. W., Rapid Prortotyping –Laser Based and Other Technologies, Kluwer,2004.

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
SEMESTER-V
Manufacturing Processes

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Gain an understanding and appreciation of the breadth and depth of the field of Manufacturing Engineering.
2. Understand the various basic Production Processes and Machine Tools.
3. Learn how to select a particular production process for the given component from the available conventional as well as non-conventional manufacturing processes.
4. Learn development and application of advanced technologies and components & processes for Manufacturing.
5. to select a particular manufacturing process for the given component from theavailable conventional as well as non conventional manufacturing processes.

Unit 1 **(5 hrs)**

Casting Processes, Expendable Mould Casting Processes: Sand Casting, types of pattern materials, pattern making allowances, core prints, moulding sand properties and testing, hand and machine moulding, core, core boxes, melting and pouring, study of furnaces – cupola, fuel fired, electric arc, induction furnaces. Investment casting, shell moulding. Casting techniques of cast iron, steels and nonferrous metals of alloys; solidification; design of casting, gating and riser in Cleaning, finishing and heat treatment of castings, defects in casting, Permanent Mould Casting Processes, Die casting, low-pressure permanent mould casting – hot and cold chamber processes, centrifugal casting, semi-centrifugal casting, centrifuging, continuous casting.

Unit 2 **(6 hrs)**

Turning, Boring, Related Processes: Fundamentals of turning and boring, lathe – construction, accessories, operations. ThreadCutting – single and multistart threading, Different tools, tool materials, tool geometry. Concept of speed, feed, depth of cut. Capstan and Turret Lathe- Construction, Working and Applications.Introduction to boring machines – general arrangement and nature of work done.

Unit 3 **(7 hrs)**

Drilling and Milling Machines

Drilling: Fundamentals of drilling process, twist drill geometry, tool holders. Types of drilling machines, operations performed on drilling machines. Types of drills. Reaming process, reamers types, geometry.

Milling Machines: Fundamentals of milling process, cutters - types and geometry. Operations performed on milling machines. Dividing head, methods of indexing. Gear train calculations for helical and cam milling.
Shaper, Planer and Slotting Machines:Construction, working of quick return mechanism, operations performed.

Unit 4 **(7 hrs)**

Abrasive Machining Processes: Abrasive machining, abrasives - types, size and geometry. Grinding wheels, wheel marking, wheel selection, wheel mountings. Types of grinding machines. Honing, Lapping, Super Finishing, Buffing.
Surface treatment processes
Honing, lapping, buffing, polishing, honing tools, lapping materials. Abrasive, buffing, polishing wheels and burnishing processes.Electroplating, Electroless plating, plasma coating, phosphating, galvanizing, metal spraying, anodizing, rubbling and tumbling.

Unit 5 **(7 hrs)**

Hot and cold working of metals: Principles of rolling, forging, drop, press, upset, roll forging, extrusion, drawing, spinning, effectsof hot working. Cold working processes, Cold rolling, swaging, forging, extrusion- forward,backward and impact roll forming, tube drawing, wire drawing, spinning, shot penning, highenergy rate forming.

Unit 6 **(7 hrs)**

Joining Processes: Welding Processes: Theory, control and applications, Arc Welding – SMAW, GTAW, GMAW,FCAW, Submerged arc welding, etc.
Resistance welding – theory, Spot, Seam, Projection welding processes etc., Gas welding. Friction welding, Ultrasonic welding, Thermit welding, Electron beam and Laser welding. Defects in welding, their cause and remedy, weldability, welding of dissimilar metals. NDT and other methods of testing welded joints. Soldering and Brazing applications. Use of adhesives for joining. Classification of adhesives, types of adhesives and their applications, surface preparation and various joints.

Textbooks:

- S.K. Hajra Choudhary and S.K. Bose, Elements of workshop Technology, Volume I, II, Asia Publishing House, 10th Edition 2000.
- P.N. Rao, Manufacturing Technology, Tata McGraw-Hill Publishing Limited, II Edition, 2002.

Reference Book:

- Chapman W.A.J, Workshop Technology, Volume I, II, III, CBS Publishers and distributors.5th Edition 2002
- Degarmo, Black and Kohser, Materials and processes in Manufacturing, Prentice Hall of India.2nd Edition 1998
- Milton Shaw, Metal Cutting Principles, Oxford University Press, 4th Edition 2001
- O.P. Khanna and M. Lal, Production Technology, Vol. I,II, Dhanpatrai Publication, 5th Edition,1999.

- B.S. Raghuwanshi, Workshop Technology, Dhanpat Rai Publication, 9th Edition, 1999.

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
SEMESTER-VI

Engineering Economics and Operations Research

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Gain an understanding and appreciation of the breadth and depth of the field of Manufacturing Engineering.
2. Understand the various basic Production Processes and Machine Tools.
3. Learn how to select a particular production process for the given component from the available conventional as well as non-conventional manufacturing processes.
4. Learn development and application of advanced technologies and components & processes for Manufacturing.
5. To be able to select a particular manufacturing process for the given component from the available conventional as well as non-conventional manufacturing processes.

Unit 1 **(6 hrs)**

Engineering Economy: Introduction, Importance, Time value of money, Net present value, Payback period, Return on investment, Internal rate of return, Equity, Shares, Dividends.

Unit 2 **(6 hrs)**

Accounting tools: Income statement, Project cash flow statement, Cost estimation, LCC estimation, capital cost estimation, Turnover ratio, Lang's factor, operating cost, marginal cost estimation, evaluation of economic alternatives, profit planning and break-even analysis.

Unit 3 **(8 hrs)**

Decision making under deterministic model: Simplex method, linear programming, deterministic inventory model, Assignment technique, Replacement etc.

Unit 4 **(8 hrs)**

Decision making under probabilistic model: Theory of games, Queuing theory and simulation, Stock control under uncertainty.

Unit 5 **(6 hrs)**

Sequencing Models: Scheduling and sequencing. Assumptions in sequencing models. Processing “n” jobs on machines. Processing of two jobs on machines with each having different processing order

Unit 6 **(6 hrs)**

Network Models: Introduction to PERT / CPM and its importance in project management. (Concepts and construction of network diagrams. Critical path and project duration, floats, network crashing, optimum project duration and cost, PERT activity, time estimate, probability of completion of a project on before specified time, Resource allocation and load smoothening.

Textbooks:

- C. B.Gupta -Fundamentals of Business, Sultan Chand & Co
- Gupta P. K. and Hira D. S. -Operations Research, S Chand & Company Ltd.

Reference Book:

- KR Sharma - Fundamentals of Engineering economy, Cognella, , the United States of America,2011
- Henry M. Stenier - Engineering economics Principles, Mc Grow hill Publication.
- P. A. Samualson -Economics, Mc Grow hill International.
- Colin Drury - Management and Cost Accounting, English Language Book Society, Chapman & Hall Landon.
- Sharma J. K. -Mathematical Models in Operations Research, Tata McGraw – Hill
- Publishing Company Limited.
- Engineering economy- web based course- Georgia university, USA

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
SEMESTER VII
Manufacturing Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. To have an overview of manufacturing, manufacturing operations and automation technologies
2. To study the definition and elements of Mechatronics and automation system
3. To learn how to apply the principles of Mechatronics and automation for the development of productive and efficient manufacturing systems.
4. To study the hydraulic and pneumatic systems employed in manufacturing industry.
5. To study material handling technologies for their identification in automated material control purposes.
6. To learn the integration of automation technologies and material handling technologies into manufacturing systems.

Unit 1 **(8 hrs)**

Overview of Manufacturing: Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics.

Automation, Mechatronics and Control Technologies:Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Microsensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

Unit 2 **(8 hrs)**

Material Handling and Identification Technologies: Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Automated Guided Vehicle System (AGVS), Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture

Manufacturing Systems: Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems

Unit 3 **(6 hrs)**

Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis: Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

Unit 4 **(6 hrs)**

Programmable Automation (Processor): Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly language programming of microcontroller

Unit 5 **(8 hrs)**

Control System and Controllers: Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions

Discrete Control: Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC

Unit 6 **(6 hrs)**

Mechatronic Systems: Control Architectures, Design Strategy and Case StudiesIntroduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems

Textbooks:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGrawHill

Reference Book:

- N. P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGraw Hill
- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw Hill
- HMT Ltd. Mechatronics, Tata McGraw-Hill
- Joji P. Pneumatic Controls, Wiley India

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
Semester VIII
Industrial Design of Products

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Students learn basics of product design process and morphology of design.
2. Students are exposed to Concept design, detail design, manufacturing, marketing, Introduction strategy of new product.
3. Students learn about process of design for production of metal components.
4. To understand optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
5. To understand all phases of product. Concept to final manufacturing

Unit 1 **(5 hrs)**

Introduction To Product Design: Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design Phases and flowcharting, Role of Allowance Process Capability, and. Tolerance in Detailed Design and Assembly.

Unit 2 **(8 hrs)**

Product Design Practice And Industry: Introduction, Product Strategies Time to Market, Analysis of the Product, The Three S's, Standardization Renard Series (Preferred Numbers), Simplification, The Designer and their Role, The Designer: Myth and Reality, The Industrial Design Organization Basic Design Considerations, Problems faced by Industrial Designer. Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers, What the Designer contributes, Role of Aesthetics in Product Design, Functional Design Practice. Review of Strength, Stiffness and Rigidity Considerations in Product Design Principal Stress Trajectories (Force - Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience, Designing for Uniform Strength, Tension vis-à-vis Compression.

Unit 3 **(8 hrs)**

Design for Production -Metal Parts: Producibility Requirements in the Design of Machine Components, Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, The Role of Process Engineer, Ease of Location and Clamping, Some Additional Aspects of Production Design, Die Casting and Special Castings, Design for Powder Metallurgical Parts, Expanded Metals and Wire Forms.

Designing with Plastics, Rubber, Ceramics and Wood: Approach to Design with Plastics, Plastic Bush Bearings, Gears in Plastic, Fasteners in Plastic,Rubber Parts, Design Recommendations for Rubber Parts, Distortion in Rubber, DimensionalEffects, Tolerances, Ceramics and Glass Parts, Production Design Factors for Ceramic Parts,Special Considerations for Design of Glass Parts, Dimensional Factors and Tolerances, Wood.Design for assembly and disassembly.

Unit 4 **(8 hrs)**

Rapid Prototyping: Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereo lithography etc.), Typical Process Chain forRP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit 5 **(8 hrs)**

Economic Factors Influencing Design: Product Value, value analysis, design for Safety, Reliability and Environmental Considerations, Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).

Human Engineering Considerations in Product Design: Introduction, Human being as Applicator of Forces, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6 **(6 hrs)**

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD) for design, product design optimization methods

Textbooks:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rd Edition, 2003

Reference Book:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, TAC-1997.
- Roland EngeneY.,Inetoviez, New Product Development: Design &nalysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod & DewburstP.,Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto and Kristini Wood, Product Design Pearson Education 2004.
- Venuvinod, PK., MA. W., Rapid Prortotyping –Laser Based and Other Technologies, Kluwer,2004.

HONORS- Manufacturing Systems Engineering
SEMESTER-V
Precision Engineering

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. The meaning precision machining and the importance of it.
2. The requirements of machine network elements to achieve precision in the components.
3. The principles of various precision engineering processes and apply them in actual field.
4. Various method of micromachining using LASER and other processes.
5. To posses basic knowledge related to new trends in manufacturing and its precise control.

Unit 1 **(7 hrs)**

Precision engineering: Introduction – Precision, Accuracy & Smoothness – Need – Development of overall machining precision Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility.

Unit 2 **(7 hrs)**

Precision machine element: Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers – Rolling elements – hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings-Hybrid gas bearings-materials for bearings.

Unit 3 **(7 hrs)**

Error Control: Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control errors due to locations – principle of constant location surfaces.

Unit 4 **(7 hrs)**

Precision Manufacturing: Micro machining processes-diamond machining - micro engraving - Micro replication techniquesforming-casting-injection moulding - micro embossing - Energy assisted processes LBM, EBM, FIB, Micro electro discharge machining-photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition.

Unit 5 **(7 hrs)**

MEMS: Introduction – MEMS –characteristics- principle – Design – Application: automobile, defence, health care, Industrial, aerospace etc.,

Unit 6 **(7 hrs)**

Micromachining: Laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation. LIGA, S-LIGA 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

Textbooks:

- Venkatesh V.C. and Izman S., —Precision Engineering‖, Tata McGraw Hill, 2007.
- Murthy R.L., —Precision Engineering‖, New Age International, 2009

Reference Book:

- Nakazawa H., —Principles of Precision Engineering‖, Oxford University Press, 1994.
- Institute of Physics Publishing, Bristol and Philadelphia, Bristol, BSI 6BE U.K

HONORS - Manufacturing Systems Engineering
SEMESTER-VI
Reliability and Maintenance Engineering

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Student will be able to understand the importance and assessment of reliability and maintainability.
2. Student will be able in a position to analyze reliability in designing and maintenance of product.
3. Student will be aware of several maintenance strategies for wide range of application.
4. Students will able to use and apply analytical methods of maintenance.

Unit 1 **(6 hrs)**
Fundamental concepts of reliability, maintainability: Definition, Failure pattern, Distribution, Life characterization phases, MTBF, MTTF etc.

Unit 2 **(8 hrs)**
Component and system reliability: Probability distribution of failure, Component reliability estimation, Conditioning probability, Parallel and series combination, Redundancy etc.

Unit 3 **(8 hrs)**
Maintainability and availability: Objectives, factors affecting them, Markov chain analysis, fault tree analysis, FMECA etc, RPN, evaluation of availability.

Unit 4 **(6 hrs)**
Maintenance models and strategy: Preventive and corrective maintenance TPM, CBM, RCM et

Unit 5 **(6 hrs)**
Analytical methods in maintenance: Optimal inspection frequency, Corrective maintenance planning under CBM- mathematical model, Repair limit model, opportunistic maintenance policy.

Unit 6 **(6 hrs)**

5n: Software maintenance cost, medical equipment maintenance and repair, spare parts inventory models, Optimal overhaul internal model, human related maintenance activity, robot maintenance under maximum profit.

Textbooks:

- L. S. Srinath - Reliability Engineering, -Affiliated East -West press, 2002.
- S.K. Basu&B.Bhadury- Terotechnology: Reliability Engg& maintenance Management, Asian book Private Ltd., Delhi, 1stEdition, 2003.

Reference Book:

- L Lamberson, KC Kapur - Reliability in engineering design- John Wiley & Sons, 1977.
- K. K. Ahuja - Industrial management and Organizational Behaviour, Khanna Publications.
- 1999
- H. P. Garg - Industrial Maintenance, S. Chand & company. Ltd, Third Edition 1990.
- Dr. Shankar - Industrial engineering Management Golgotia Publications Pvt. Ltd. 1997
- B.S. Dhillon- Maintainability, Maintenance, and Reliability for Engineers, CRC press, taylor and francis group, 2006
- Charles Ebeling- An introduction to reliability and maintainability engineering, Tata macgraw- Hill, 1997.
- Plant engineering handbook
- LC Morrow - Maintenance engineering handbook,McGraw-Hill, 2nd ed, 1966,

HONORS - Manufacturing Systems Engineering
SEMESTER-VII
Performance Modeling of Production Systems

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Identify the type of Production system and its modeling.
2. Perform line balancing and buffer stock simulation.
3. Analyze the production system using Markov chain & Petri Net..
4. To understand how AGV are used in the production systems.
5. Use of Petri Nets in the production systems

Unit 1 **(6 hrs)**
Fundamental concepts of reliability, maintainability: Definition, Failure pattern, Distribution, Life characterization phases, MTBF, MTTF etc.

Unit 2 **(8 hrs)**
Component and system reliability: Probability distribution of failure, Component reliability estimation, Conditioning probability, Parallel and series combination, Redundancy etc.

Unit 3 **(8 hrs)**
Maintainability and availability: Objectives, factors affecting them, Markov chain analysis, fault tree analysis, FMECA etc, RPN, evaluation of availability.

Unit 4 **(6 hrs)**
Maintenance models and strategy: Preventive and corrective maintenance TPM, CBM, RCM et

Unit 5 **(6 hrs)**
Analytical methods in maintenance: Optimal inspection frequency, Corrective maintenance planning under CBM- mathematical model, Repair limit model, opportunistic maintenance policy.

Unit 6 **(6 hrs)**
5n: Software maintenance cost, medical equipment maintenance and repair, spare parts inventory models, Optimal overhaul internal model, human related maintenance activity, robot maintenance under maximum profit.

Textbooks:

- N. Viswanadhan & Y. Narahari, "Performance Modelling of Automated Manufacturing Systems", Prentice Hall of India (Eastern Economy Edition) 1992.

Reference Book:

- Mikell P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing" Prentice Hall India Learning Pvt. Ltd.3rdEdition. 2008
- Benjamin S. Blanchand, "Logistics Engineering and Management (5th Edn.) - Pearson Education Asia - Indian Reprint 2001

HONORS - Manufacturing Systems Engineering
SEMESTER-VIII

Machine Tool System

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. To get up to-date knowledge in machine tool development field
2. To understand basic design principles of macro/micro elements of system.
3. To understand machine tool utilization to increase effective productivity.
4. To learn machine tool structure and their elements
5. To understand basic design features of machine elements

Unit 1 **(6 hrs)**

Machine tool configuration: Recent development in machine tool field, Basic concepts and requirements, types of machine tool, structure of machine tool system, Design approach by matrix method, Introduction to CNC and machining centre configuration.

Unit 2 **(6 hrs)**

Drive system review: Elements of machine tool system, their requirements and design criteria-drive system viz speed/ feed drive, power transmission screw etc

Unit 3 **(8 hrs)**

Supporting elements and design analysis: Supporting elements in machine tool-like bed, guides and lubrication, and stick slip, spindle, Machine column etc.

Unit 4 **(6 hrs)**

Rigidity & reliability of machine tool: Rigidity of machine tool-static and dynamic, dynamic characterization analysis of cutting process, vibration and chatter, Machine compliance estimation, Tobius curve etc. Reliability of machine tool, Availability etc.

Unit 5 **(6 hrs)**

Automation and feedback: Open loop and closed loop control, pre-selective and selective control, micro movements of elements, micro sensors, electrical/electronic control of motor, hydraulic controls, in-process gauging etc.

Unit 6 **(8 hrs)**

Introduction to modern machine tool: Principle of automation, multi-axis machining centres, additive manufacturing machines, super finishing machines etc., machine tool power utilization with full tool life, Machine tool performance(Coefficient of merit).

Textbooks:

- S K Basu, D. K. Pal - Design of Machine Tools, Oxford & IBH Pub., 1995
- Gopal Chandra Sen, Amitabha Bhattacharyya - Principles of Machine Tools, New Central Book Agency, 1967

Reference Book:

- N. Ignatyev, N. Acherkan et al - *Machine Tool Design*, Volume 4, University Press of the Pacific, 2000.
- N K Mehta - *Machine tool design and Numerical control*, third edition, Tata McGraw hill publications limited, 2012
- Stanley John Martin-*Numerical Control of Machine Tools*, Hodder and Stoughton, 1970
- T.K. Kundra- *Numerical Control and Computer-Aided Manufacturing*, McGraw-Hill Education, 1987
- JW Gardner, F Udrea- *Microsensors: principles and applications*,2nd John Wiley & Sons, 2009.
- A Gebhardt, A Gebhardt- *Understanding additive manufacturing*,CarlHanser Verlag GmbH & Co.,2012.
- RS Schmid, S Kalpakjian- *Manufacturing engineering and technology*, Pearson Prentice Hall, 2006.
- B Lu, D Li, X Tian- *Development Trends in Additive Manufacturing and 3D Printing*,Engineering, vol-1,issue-1,2015
- Menz et al - *Microsystem technology* - wileyvch verlag,2000

Honors- Mechatronics
Bridge Course (Mechanical/Electronics)
Semester V
Principles of Electronics

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. To develop and employ circuit models for elementary electronic components, e.g., resistors, sources, inductors, capacitors, diodes and transistors;
2. Become adept at using various methods of circuit analysis.
3. Be able to use basic techniques for analyzing analogue and digital electronic circuits
4. Be able to understand basic methods of control systems

Role of various Engineering disciplines in Mechatronics, Mechatronics Design elements, Scope and Applications of Mechatronics, Analog electronic components and devices, Oscillators as signal generators, Power supplies and voltage regulators, Power Electronics-Devices, Industrial electronic circuits, Digital Electronics- Arithmetic circuits, Multiplexers/Demultiplexers, Registers, Counters, Memories, Few examples of transducers, Signal conditioning Circuits using Operational amplifiers, Noise Problems, Grounding and shielding, Data acquisition systems,-Single channel and multichannel, Data loggers, Control Systems Components, Classification of Control Systems, Transfer functions, Time and Frequency response Analysis tools.

Textbooks:

- Allen Mottershed, "Electronic Devices and Circuits", Prentice Hall International, Third Edition

Reference Book:

- M. D. Singh and J. G. Joshi, "Mechatronics – Principles and Applications", Prentice Hall India publication-EEE.

Honors – Mechatronics
Bridge Course (Mechanical/Electronics)
Semester VI
Industrial Instrumentation and Control

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. An ability to identify, formulate and solve a problem of Instrumentation and Control Engineering
2. An ability to design and conduct experiments for measurement and ability to analyze and interprets data.
3. Demonstrate an understanding of sensors / transducers.
4. Able to understand and use various types fuses, breakers etc.

General concepts and terminology of measurement systems, static and dynamic characteristics, errors, standards and calibration. Introduction, principle, construction and design of various active and passive transducers. Introduction to semiconductor sensors and its applications. Design of signal conditioning circuits for various Resistive, Capacitive and Inductive transducers and piezoelectric transducer. Introduction to transmitters, two wire and four wire transmitters, Smart and intelligent Transmitters. Design of transmitters. Introduction to EMC, interference coupling mechanism, basics of circuit layout and grounding, concept of interfaces, filtering and shielding. Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety.

Textbooks:

- M. Sze, "Semiconductor sensors", John Wiley & Sons Inc., Singapore, 1994.
- Noltingk B.E., "Instrumentation Reference Book", 2nd Edition, ButterworthHeinemann, 1995.
- L.D.Goettsche, "Maintenance of Instruments and Systems – Practical guides for measurements and control", ISA, 1995.

Reference Book:

- John P. Bentley, Principles of Measurement Systems, Third edition, Addison
- Wesley Longman Ltd., UK, 2000.

- Doebelin E.O, Measurement Systems - Application and Design, Fourth edition,McGraw-Hill International Edition, New York, 1992.

Honors – Mechatronics
Bridge Course (Mechanical/Electronics)
Semester VII
Fluid Power Systems and Factory Automation

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Aware of the importance and the scope of hydraulics and pneumatics in the modern industry.
2. Able to select and size the different components required to design a fluid power system.
3. Able to select a control system to control the operation of designed fluid power system.
4. Able to design and implement low-cost automation system.

Hydraulic Power Generators - Selection and specification of pumps, pump characteristics.
Linear and Rotary Actuators - selection, specification and characteristics.
Pressure - direction and flow control valves - relief valves, non return and safety valves - actuation systems.
Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits - industrial circuits – press circuits - hydraulic illing machine - grinding, planning, copying, forklift, earth mover circuits - design and selection of components - safety and emergency mandrels.
Pneumatic fundamentals - control elements, position and pressure sensing
Pneumatic logic circuits - switching circuits -fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods – step counter method - compound circuit design - combination circuit design.
Pneumatic equipments - selection of components - design calculations -application - fault finding – hydro pneumatic circuits –
Use of microprocessors/microcontrollers for sequencing - PLC, Low cost automation - Robotic circuits.

Textbooks:

- Antony Esposito, "Fluid power with Applications", Prentice Hall India, 7th Edition, 2014.
- Dudleyt, A.Pease and John J.Pippenger, "Basic Fluid Power", Prentice Hall, 1987.
- Andrew Parr, "Hydraulic and Pneumatic", Jaico Publishing House, 1999.

Reference Book:

- Bolton. W. "Pneumatic and Hydraulic Systems", Butterworth - Heinemann, 1997.
- Anthon H. Hehn, "Fluid Power Troubleshooting", 2nd Edition, Marcel Dekker.
- S. R. Majumdar, "Pneumatic Systems: Principles and Maintenance", Tata McGrawHill Publishing Company Limited, 1995.

Honors- Mechatronics
Bridge Course (Mechanical/Electronics)
Semester VIII
Mechatronics System Design

Teaching Scheme
Lectures: 3 hrs./week

Examination Scheme
Test I - 20 Marks
Test II - 20 Marks
End Sem Exam - 60 marks

Course Outcomes:
At the end of the course, students will demonstrate the ability to

1. Demonstrate how Mechatronics integrates knowledge from different disciplines in order to realize engineering and consumer products that are useful in everyday life.
2. Application of theoretical knowledge: understanding selection of suitable sensors and actuators; designing electro-mechanical systems.
3. Technical work: working with mechanical systems that include digital and analogue electronics as a data acquisition model.
4. Students should possess theoretical knowledge and make students familiar to select suitable sensors and actuators while designing electro-mechanical systems.
5. To demonstrate technical requirement while working with Mechatronics Systems.

Rotational drives - Pneumatic Motors: continuous and limited rotation - Hydraulic Motors: continuous and limited rotation - Brushless DC Motors - Motion convertors, Fixed ratio, invariant motion profile, variators, remotely controlled couplings Hydraulic Circuits and Pneumatic Circuits.
Mechanical Systems and Design - Mechatronics approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.
Real time interfacing - Introduction Elements of data acquisition and control Overview of I/O process-Installation of I/O card and software - Installation of application software-Over framing.

Case studies on Data Acquisition - Transducer calibration system for Automotive applications Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Controlling temperature of a hot/cold reservoir -Pick and place robot - Carpark barriers.

Case studies on Data Acquisition and Control - Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.

Case studies on design of Mechatronics products - Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.

Textbooks:

- W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.
- Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997

Reference Book:

- Bradley, D.Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products
- and Processes, Chapman and Hall, London, 1991.
- Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
- Gopal, Sensors- A comprehensive Survey Vol I & Vol VIII, BCH Publisher.