COEP Technological University [COEP Tech]
(A Unitary Public University of Government of Maharashtra)
(Formerly College of Engineering Pune [COEP])

Department of Manufacturing Engineering and Industrial Management

NEP Compliant Curriculum Structure (UG Program)

B. Tech. (Manufacturing Science and Engineering)
(Effective from: A.Y. 2023-24)

List of Abbreviations:

Abbreviation	Title	No of courses	Credits	% of Credits
BSC	Basic Science Course	**5**	**14**	**8.75**
ESC	Engineering Science Course	**6**	**16**	**10**
PCC	Programme Core Course	**19**	**54**	**33.75**
PEC	Programme Elective Course	**6**	**20**	**12.5**
OE/SE	Open/School Elective (other than particular program)	**3**	**6**	**3.75**
MDM	Multidisciplinary Minor	**5**	**14**	**8.75**
VSEC	Vocational and Skill Enhancement Course	**5**	**6**	**3.75**
AEC-01	Ability Enhancement Course	**1**	**2**	**1.25**
AEC	Indian Language	**1**	**2**	**1.25**
HSSM	Entrepreneurship/Economics/ Management Courses	**2**	**4**	**2.5**
IKS	Indian Knowledge System	**1**	**2**	**1.25**
VEC	Value Education Course	**2**	**2**	**1.25**
RM	Research Methodology	**1**	**2**	**1.25**
CEA	Community Engagement Activity /Field Project	**1**	**2**	**1.25**
CCA	Co-curricular & Extracurricular Activities	**2**	**2**	**1.25**
INT	Internship	**3**	**12**	**7.5**
	Total	**63**	**160**	**100**

UG Program Structure of Semester- V and VI
of
B. Tech. (Manufacturing Science and Engineering)

Semester V -(WEF AY 2025-26)

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	PCC	MFG-25001	Metrology & Quality Control	2	0	2	1	3	30	20	50	CIE-100	
2	PCC	MFG-25002	Process Planning & Tool Design	2	0	2	1	3	30	20	50	CIE-100	
3	PCC	MFG-25003	Industrial Engineering and Management	2	0	0	1	2	30	20	50		
4	PCC	MFG-25004	Kinematics and Dynamics of Machines	3	0	0	1	3	30	20	50		
5	PEC	MFG(PE)-25001-05	Department Elective-I	3	0	2	0	4	30	20	50	CIE-100	
6	OE	OEC25007	Open Elective-III	2	0	0	0	2	30	20	50		
7	MDM		Multidisciplinary Minor-III	3	1	0	0	4	30	20	50		
8		MFG-25005	Project stage-I	0	0	4	0	2				CIE-100	
9		MFG-25006	Internship-II#	0	0	2	0	1				CIE-100	
Total Academic Engagement and Credits				17	0	16	4	24					

 # Summer internship-II (Industry/R&D/Academic institute) after IVth semester summer vacation and evaluation will be done at the start of Vth semester.

Programme Elective Courses (PEC-1)- Semester-V

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	PEC 1	Product Design and Development	3	0	2	0	5	4
2	PEC 1	Tribology in Design & Manufacturing	3	0	2	0	5	4
3	PEC 1	Mechatronics	3	0	2	0	5	4
4	PEC 1	Metal Forming Technology	3	0	2	0	5	4
5	PEC 1	Additive manufacturing	3	0	2	0	5	4

Open Elective-III

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	OE	Operation Research	2	0	0	0	2	2
2	OE	Reliability Engineering	2	0	0	0	2	2

Semester VI- (WEF AY 2025-26)

Sr. No.	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme (Weightages in %)				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
1	PCC	MFG-25007	Advances in CAD/CAM/CIM	2	1	2	1	4	30	20	50	CIE-100	
2	PCC	MFG-25008	Operations Research	3	0	0	1	3	30	20	50	--	--
3	PCC	MFG-25009	Manufacturing Automation	3	0	2	1	4	30	20	50	CIE-100	
4	PEC	MFG(PE)-25006-10	Department Elective -II	3	0	2		4	30	20	50	CIE-100	
5	MDM		Multidisciplinary Minor	3	1	0	1	4	30	20	50	--	--
6	VSEC	MFG-25010	Smart Mfg. and Simulation Laboratory	0	0	2	1	1				CIE-100	
7		MFG-25011	Project stage-II	0	0	2	1	2				CIE-100	
Total Academic Engagement and Credits				14	2	10	6	22					

Summer internship-III (Industry/R&D/Academic institute) after semester-VI during summer vacation and evaluation will be done in the VIIth semester.

Programme Elective Courses (PEC-2) - Semester-VI

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	PEC 2	Design For Manufacturing and Assembly	3	0	2	0	5	4
2	PEC 2	Micro & Nano manufacturing	3	0	2	0	5	4
3	PEC 2	Advanced Joining Techniques	3	0	2	0	5	4
4	PEC 2	AI for Manufacturing	3	0	2	0	5	4
5	PEC 2	Fundamentals of Quantitative Techniques in Project Management	3	0	2	0	5	4

Exit Course options for B.Voc in Manufacturing Sciences

Two (02) Skill based Courses of 8 credits

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	SEC	Computer Aided Inspection	0	0	8	1	5	4
2	SEC	Casting & Welding Technology	0	0	8	1	5	4

Project based Internship-III should be done in VIIIth semester.

Semester Wise Credit Distribution	Teaching Scheme					Credits
	L	T	P	S	Hrs	
I	11	1	16	6	28	20
II	13	1	12	8	26	20
III	16	0	10	8	26	20
IV	15	0	14	5	29	22
V	17	0	12	4	29	24
VI	13	2	10	6	25	22
VII	17	0	10	7	27	20
VIII	6	0	12	4	18	12
Total Academic Engagement and Credits	**108**	**4**	**96**	**48**	**208**	**160**

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Course: METROLOGY AND QUALITY CONTROL (MQC)

Course Code	MFG-25001	**Scheme of Evaluation**	MSE, TA & ESE	Scheme of Evaluation for Lab	CIE
Teaching Plan	2-0-2-1 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	3	**ESE**	50 Marks		

Course Objectives:

1. Selection of Tools and Techniques for determining geometry and dimensions
2. Calibration of measuring tools
3. Understand the advances in Metrology such as use of CMM.
4. Application of Quality Control Techniques.

Syllabus:

Unit	Contents	Lecture
01.	**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. **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. *Self Study*- Angle Measurement: Sine bar, Sine centres, Uses of sine bars, angle gauges, Auto Collimator, Angle dekkor, Constant deviation prism.	**06 L**
02.	**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:** GD&T symbols and concept,Straightness, Flatness, Parallelism, Concentricity, Squarenessand Circularity. *Self Study*- Comparators:Uses, Types, Advantages and Disadvantages of various types of Comparators.Multigauge Measurement Systems.	**05 L**
03.	**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.	**05 L**

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.
Self Study- Gear Metrology**:** Spur Gear Parameters, Gear tooth thickness measurement: Gear tooth verniercalliper, Constant chord method, Span Micrometer.

04. **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, Quality Assurance system and standards. **03 L**
Self Study-Total Quality Management: 7 Tools of problem solving, Like cause and effect diagram, Pareto Analysis ,etc. QFD, Kaizen, 5s system, Quality Circles

05. **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 (Cp, Cpk), Concept, Methods of determining Cp and Cpk. **05 L**
Self Study-ISO 9001-2000 Series of Standards: History and evolution of ISO 9000 series, importance and overview of ISO series, Structure of ISO 9001-2000 Series Standards, clauses of ISO 9000 series standards and their interpretation and implementation

METROLOGY AND QUALITY CONTROL LAB SYLLABUS:
Term work consists of following experiments (Any Eight)

Assignment	Contents	Practical
01	Determination of Linear/Angular dimensions of a part using Precision and Non-Precision measuring Instruments.	**02hrs**
02	Precision angular measurement using a) Sine Bar, b) Auto Collimator, c) Angle Dekkor.	**02hrs**
03	Machine Tool alignment tests on any machine tool like Lathe, Drilling Machine or Milling machine (minimum three tests)	**04hrs**
04	Measurement of screw thread parameters using Floating Carriage Micrometer.	**02hrs**
05	Measurement of Gear parameters: a) Gear Tooth thickness and depth, b) constant Chord, c) Span Measurement, d) Pitch Circle Diameter.	**02hrs**
06	Surface Finish measurement using suitable instrument	**02hrs**
07	Interferometry: Measurement of surface flatness using optical flat.	**02hrs**
08	Study and Measurement of parameters using Profile Projector.	**04hrs**
09	Exercise on Design of Limit Gauges using Taylor's Principles.	**02hrs**
10	Study and Measurement of parameters using Tool Makers Microscope.	**02hrs**
11	Study and Measurement of parameters using Co-ordinate measuring machine (CMM).	**02hrs**
12	Measurement of circularity using comparator	**02hrs**

Course outcomes:
1. Identify different measurement systems and common types of errors.

2. Describe and use different types of linear and angular measurement processes and instruments.
3. Explain and able to select appropriate techniques of interferometers, comparators and screw and gear measurements.
4. Explain surface roughness measurements, Optical instruments and 3Dmeasurements.
5. Explain industrial practices to analyze the cause for variation by statistical process control using variable and attribute control charts and sampling technique.
6. Explain principle, construction and working of various measuring instrument,.
7. Selection of proper instruments for measurement.
8. Calculation of least count of instrument, take reading using the instrument.

Suggested learning resources:

Text Books:

1. R. K. Jain, A Textbook of Engineering Metrology, Khanna Publications Pvt. Ltd.22nd Edition, 2022.
2. Dr.S.P. Gupta, Statistical Methods, Sultan Chand and Sons, 46th Edition, 2021.
3. Grant and Leavenworth," Statistical Quality Control", McGraw Hill publication,2017
4. Amitava Mitra, Fundamental of Quality Control and improvement, Prentice Hall of India Publications, 4th Edition 2016
5. I.C. Gupta, A Text book of Engineering Metrology, Dhanpat Rai Publications Pvt. Ltd.6thEdition, 2004

Reference Books:

1. G.M.S. De Silva, Basic Metrology for ISO 9000 Certification Elsevier Publications, 3rd Edition 2002.
2. A.S.T.M.E., "Handbook of Industrial Metrology", Prentice Hall, ISBN 10: 0070015368, 1968.
3. G.S. Patnaik, Quality Assurance in Industries: A Comprehensive Guide to Quality Assurance in Industries, Notion Press Media Pvt. Limited, ISBN: 9781639403134, 1639403132.
4. Kumar D S," Mechanical Measurements and Control" Metropolitan publication, Delhi.,5th edition,2012
5. John S. Oahland, Total Quality Management, Elsevier Publications, 3rd Edition 2006.
6. P. N. Mukerjee, Total Quality Management, Prentice Hall of India Publications, 2nd Edition 2005

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Course: PROCESS PLANNING AND TOOL DESIGN (PPTD)

Course Code	MFG-25002	**Scheme of Evaluation**	MSE, TA & ESE	Scheme of Evaluation for Lab	CIE
Teaching Plan	2-0-2-1 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	3	**ESE**	50 Marks		

Course Objectives

1. To analyse part drawings for dimensions, tolerances, geometric controls, and surface requirements to support accurate and precise manufacturing planning.
2. To select appropriate manufacturing processes, cutting tools, jigs, and fixtures based on component geometry, material, and production requirements.
3. To plan and analyse systematic process planning and sequencing, including selection of datums, machining operations, stock allowances, and preparation of process sheets for efficient production.
4. To optimize the design parameters and tooling methods for press tools, dies and punches, forging dies, die casting dies, and plastic moulds to improve productivity, quality, and cost-effectiveness.

Syllabus:

Unit	Contents	Lecture
01.	**Fundamentals of Process Planning:** Introduction: basics of process planning, designing production workflow, tolerances, part features to manufacturability. Datum features, geometric accuracy, preliminary part print analysis, dimensioning, tolerances, and critical control features. Self study: Interpretation of engineering drawings, part print analysis.	**06 L**
02.	**Process Selection and Sequencing:** Approach to select manufacturing processes, sequence of operations, classification of processes into basic, principal, auxiliary, and supporting operations, cost-effectiveness, importance of process sequencing, optimizing production time and quality, stock preparation, blank selection with material estimation, time estimate and time standards. Self study: Study of traditional and advanced manufacturing process.	**08 L**
03.	**Jigs and Fixtures:** Study and Selection of Tooling: Standard and Special Tooling, Significance and purpose of jigs and fixtures and their functions in the manufacturing processes. Classification of 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.	**07 L**

Self-study: Basic principle of use of jigs and fixtures, applications in industry.

04. Fundamentals of Tool Design: 05 L

Introduction to basic principles of tool design, components of press tools, design objectives, economics of design, ergonomics, material selection, classification and components of press tools: dies, punches, and their applications.

Self study: Overview of press tools, forging dies, and plastic moulds.

05. Design of Press Tools and Forging Dies: 08 L

Design principles and applications of **press tools, forging,** metal forming processes. Types of dies, calculations for blank size, center of pressure, press capacity, various forces. Design of forging dies, Guidelines for selection of various design factors, parting line, draft, rib-web, Corner & fillet radius, shrinkage & die wear etc. Calculations related to stock size, forging forces, and die wear considerations to optimize tool life and efficiency.

Self study: Study of basic principle of bending and forging process.

06. Design of Die Casting Dies and Plastic Moulds: 08L

Design considerations in die casting, feed system and flow system and ejection system, and heat transfer considerations, Common defects in die casting.

Moulding processes such as injection moulding, blow moulding, and compression moulding**.** Common defects in moulding, their remedies.

Self-study: Basic principle of die casting, plastic moulding and its components, applications.

PROCESS PLANNING AND TOOL DESIGN (PPTD) -LABORATORY SYLLABUS:

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

i. Preliminary part print analysis for given components which includes study of part, its dimensions and tolerances and control of its features of parts.

ii. 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.

iii. Analysis of Part Dimensions of given component: Shape of part as flatness, straightness, roundness, geometrical shapes, symmetry, job requirement of finish on part.

iv. 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.

v. Identification and list of 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.

vi. Study and Selection of Tooling: Standard and Special Tooling. Use of Jigs and Fixtures, Selection of Equipment, Tooling. Economics of Tooling.

vii. 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

viii. 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.

   i) Datum features/surfaces and their selection.
   ii) Stock preparations and blank selection with material estimate.
   iii) Time estimate and time standards.
   iv) Process sheet design for the complete manufacture of the machined parts

Course outcomes:

After successful completion of the course, students will be able to:

i) Analyse part drawings to evaluate dimensions, tolerances, geometric controls, and functional features of components.
ii) Select and assign appropriate manufacturing and machining process sequences, from basic to principal operations, for given components.
iii) Identify and select suitable cutting tools, jigs, fixtures, and other tooling required for major machining operations.
iv) Prepare detailed process plans, routing sheets, and flow diagrams for efficient and systematic manufacturing.
v) Analyse and comprehend the design and theoretical aspects of jigs and fixtures, press tools, and moulding dies for practical manufacturing applications.

Suggested learning resources:

Text Book:

1. Cyril Donaldson, George H. Le Cain, V.C. Goold, "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2000, 3rdEdition.
2. Vukota Boljanovic, "Sheet Metal Forming Processes and Die Design", Industrial Press, New York, 2004.
3. Wilson, Fundamentals of Tool Design, A.S.T.M.E., Prentice Hall of India.
4. S. K. Basu, S.N. Mukherjee, R. Mishra, Fundamental of Tool Engineering Design, Oxford & IBH Publishing Co. Pvt. Ltd., 1979.
5. P.C. Sharma, (2005), A Textbook of Machine Tools and Tool Design.

Reference Book:

1. J. R. Paquin, R. E. Crowley, Die Design Fundamentals, Industrial Press Inc., 2nd Edition, 1987.
2. Gideon Halevi and Roland D. Weill, (1995),) Principles of Process Planning: A Logical Approach.
3. K.G. Swift and J.D. Booker, (2013,) Manufacturing Process Selection Handbook
4. Peter Scallan Process, (2000) Planning: The Design/Manufacture Interface.

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Course: INDUSTRIAL ENGINEERING AND MANAGMENT (IEM)

Course Code	MFG-25003	**Scheme of Evaluation**	MSE, TA & ESE
Teaching Plan	2-0-0-1 = 3	**MSE+ TA**	30 + 20 Marks
Credits	2	**ESE**	50 Marks

Course Objectives:

1. To understand Industrial Engineering and Organizational Concepts – Learn the role of industrial engineering and contributions of Taylor and Gilbreth. Study organizational structures, elements, and types.
2. To analyze Authority and Responsibility in Organizations – Explore different organizational types and understand authority, responsibility, delegation, and span of control.
3. To evaluate Productivity and Its Measurement – Define productivity and analyze factors affecting it, including material, land, machine, and labor efficiency.
4. To apply Principles for Efficiency Improvement – Use industrial engineering techniques to optimize productivity, enhance workflows, and improve organizational effectiveness.

Syllabus:

Unit	Contents	Lecture
01.	**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. Self Study: Pioneers in IE	**05 L**
02.	**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. Self Study: Case study of Value Engineering/Value Analysis	**07 L**
03.	**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.	**06 L**

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.
Self Study: Application of MOST.

04. Principles of Management: **04 L**

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.

05. Methods of job evaluations and merit rating: **06 L**

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.
Self study: Numerical problems on Wage Incentives

Course outcomes:

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.

Suggested learning resources:

Text Book:

1. Work Study, ILO
2. Basu S.K., Sahu K.C and Rajiv B, Industrial Organization and Management –. PHI New Delhi, 2012, ISBN No. 9788120344211.
3. R.M. Barnes, "Motion and Time Study", Wiley International, 1980.
4. S. Dalela and Sourabh, "Work Study and Ergonomics". Standard Publishers, Latest Edition

Reference Book:

1. M.S. Sanders and E.J. McCormick, "Human Factors in Engineering Design", VI Edition, McGraw Hill.

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Course: KINEMATICS AND DYNAMICS OF MACHINES (CL)

Course Code	MFG-25004	**Scheme of Evaluation**	MSE, TA & ESE
Teaching Plan	3-0-0-1 = 4	**MSE & TA**	30 + 20
Credits	3	**ESE**	50

Course Objectives:
Students will be able to

1. Explore various applications of cam and follower by analyzing various types of motion and able to construct cam profile
2. Understand the loading pattern and stress concentrations to see its impact on machine members
3. Design the various types of gears used in industrial applications by understanding its design
4. Explore the type of Clutches, brakes and its industrial applications.
5. Understand the impact of bearing selection and its design process over its life.

Syllabus:

Unit	Contents	Lecture
01.	**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.	**06 L**
02.	**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.	**06 L**
03.	**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.	**10 L**
04.	**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.	**07 L**
05.	**Friction Clutches, Brakes:** Pivot collar friction, design consideration for plate, cone & centrifugal clutches. Design of various brakes, like band	**06 L**

	brake, shoe brake, band & block brake, Disc Brakes, thermal considerations.	
06.	**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.	**07 L**

Course outcomes:

1. To select the type of follower motion for the specific application.
2. Analyze the load-carrying members to be safe under their expected loading patterns commonly encountered by machine parts.
3. Analyze 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. Perform the design and analysis of various types of clutches and brakes to specify the required capacity to drive the given system reliably.
5. Understand bearing selection process to evaluate expected bearing life for industrial application.

Suggested learning resources:

Textbooks:

1. V.B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publishing Company Ltd., 3rd Edition, 2010.
2. S. S. Rattan, "Theory of Machines", Tata McGraw Hill Publishing Company Ltd., 3rd Edition, 2009.

Reference Book:

1. R.S. Khurmi J. K. Gupta, "Theory of Machines", Eurasia Publishing House (Pvt.) Ltd, 2nd Edition 2020.
2. R.S. Khurmi J. K. Gupta, "A Textbook of Machine Design", S. Chand Publication, 25th Edition, 2020.
3. Joseph E. Shigley, John J. Uicker, "Theory of Machines and Mechanisms", Cambridge University Press, 6th Edition, 2023.
4. Thomas Bevan, "Theory of Machines", Pearson Education, 3rd Edition. 2010.
5. Robert L. Norton, "Design of Machinery", McGraw Hill Higher Education, 5th Edition, 2012.
6. Robert L. Mott, P.E, "Machine elements in mechanical design", Pearson Prentice Hall Publication 4th Edition, 2020.

Department of Manufacturing Engineering & Industrial Management
Programme Elective Courses-1

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	PEC 1	Product Design and Development	3	0	2		5	4
2	PEC 1	Tribology in Design & Manufacturing	3	0	2		5	4
3	PEC 1	Mechatronics	3	0	2		5	4
4	PEC 1	Metal Forming Technology	3	0	2		5	4
5	PEC 1	Additive Manufacturing	3	0	2		5	4

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Course: PRODUCT DESIGN AND DEVELOPMENT

Course Code	MFG(PE)-25001	**Scheme of Evaluation**	Continuous Evaluation (CE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

1. Understand the fundamental concepts of Innovation, Product design & development.
2. Understand Product Study and market study & benchmarking along with difference in product development and product design.
3. Understand importance of Human factors in product design, Physical Ergonomics principles and issues, Ergonomic assessment tool, Cognitive issues in product design.
4. Apply concept of concurrent design, product profit and competitiveness, Break even analysis, economics of new product design.
5. Apply different considerations to solve real world product design problems.
6. Explore advanced Product design tools and their applications.

Syllabus:

Unit	Contents	Lecture
01.	**Introduction to Product Design:** Definition of Product design, Design by evolution, innovation, Essential factors of Product design, Product development team: definition, composition, team roles, Myer-Briggs type indicator, team structure, team building, team evaluation; Product Development Planning: Steps of planning, basic planning and scheduling tools; S-curves: definition, scurves, Technology readiness Levels (TRLs)..	**08L**
02.	**Product design Considerations:** Product strategies (four strategies), Time to market, Product and market, The three S's, (Standardization, Simplification, Specialization), Procedure adopted by Industrial designers, Types of models, Role of aesthetics, Functional design practice (Biasing, Cascading, Regeneration, Redundancy, Compatibility, and matching considerations in product design.	**08 L**
03.	**Customer Needs** Customer satisfaction: Kano diagram, customer populations, types of customer needs, customer need models; Customer needs gathering methods Establishing Product Function Product Teardown & Experimentation Functional Decomposition: product function, sub function, abstraction, constraints; Modeling process: Function Analysis System Technique (FAST), Subtract and Operate procedure; Function structure: phases modeling process; Function structure decomposition; Product Teardown: phases of product teardown process; teardown methods; measurement and experimentation; Post teardown reporting; application of product teardown.	**08 L**
04.	**Ergonomics in Product design:** Anthropometry, design of controls, design for displays, Man/machine interaction, Ergonomic considerations, Workplace layouts, heating and ventilations, lighting considerations.	**06 L**

05.	**Product Economics:** Design for safety, Reliability, and environmental consideration, Economic analysis, Profit and competitiveness, Break even analysis, Economics of new product design	**06 L**
06	**Rapid Prototyping:** Physical Prototypes Physical Models and Experimentation Physical models, Prototypes, Types of prototypes, uses of prototypes. Rapid prototyping techniques, Scale, Dimensional analysis, Physical prototype design and planning..	**06 L**

PRODUCT DESIGN AND DEVELOPMENT -LABORATORY SYLLABUS

(Any six laboratory assignments)

S.No	Name of the Laboratory assignment
01	Case study preparation of Product evolution of an engineering product
02	Product graphics design of any one consumer product
03	Case study preparation on customer need gathering of a product
04	Establishing of a Product Function of one concept product
05	Product Teardown of anyone engineering/consumer durable product
06	Benchmarking of anyone engineering/consumer durable product
07	Case study preparation of Ergonomic design of any one consumer durable product
08	Prototyping of a product concept using 3D Printing, Digital fabrication tools

Course outcomes:

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

1. Learn basic concepts Learn basics of product design process and morphology of design.
2. Learn Concept design, detail design, manufacturing, marketing, Introduction strategy of new product.
3. Gain learning about optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
4. Understand concurrent design, product profit and competitiveness, Break even analysis, economics of new product design.
5. Learn how to apply/ solve real world product design problems.
6. Learn about various advanced Product design tools.

Suggested learning resources:

Text Book:

1. Kevin Otto, Kristin Wood**,** *Product Design*, Pearson.
2. Karl T. Ulrich**,** *Product Design and Development*, Pearson.
3. Tim Jones**,** *New Product Development*, Butterworth-Heinemann, Oxford.
4. Roland Engene Y., Inetoviez**,** *New Product Development: Design and Analysis*, John Wiley & Sons Inc.
5. Geoffrey Boothroyd, Peter Dewhurst, Winston Knight**,** *Product Design for Manufacture and Assembly*, Amherst.

Reference Book:

1. Peter N. Golder, Debanjan Mitra, *Handbook of Research on New Product Development*, Edward Elgar Publishing, 2018**.**
2. Donald A. Norman, *The Design of Everyday Things*, Basic Books.
3. Erika Hall, *Just Enough Research*, Mule Books, 2024**.**
4. Steven Selikoff, *The Complete Book of Product Design, Development, Manufacturing, and Sales*, 2020

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Course: TRIBOLOGY IN DESIGN AND MANUFACTURING

Course Code	MFG(PE)-25002	**Scheme of Evaluation**	Continuous Evaluation (CE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

1. Introduction of tribology to explain the fundamental principles of tribology
2. Develop an understanding of various wear mechanisms
3. Enable the students with the knowledge to select appropriate lubricants:
4. Enable students to apply tribological principles to design and manufacturing:
5. Foster an understanding of the importance of tribology in Manufacturing engineering

Syllabus:

Unit	Contents	Lecture
01.	**Tribology** Introduction, Importance of Tribology in Design, Tribology in Industry, Economic Considerations, effects of surface preparation on Tribology. **Friction** Introduction, Laws of friction, kinds of friction, causes of friction, area of contact, friction measurement, theories of friction. **Wear** Types of wear, various factors affecting wear, cutting tool wear & coating, measurement of wear, wear between solids and flowing liquids, theories of wear.	**08 L**
02.	**Lubricants and Lubrication** Introduction, Lubricant properties- physical and chemical, basic modes of lubrication, types of lubricants, Seals-Static and dynamic. Tribology in manufacturing processes viz. Forging, drawing, extrusion, rolling etc. Lubricants used for wire ropes.	**06 L**
03.	**Hydrodynamic Lubrication** Theory of hydrodynamic lubrication. Mechanism of pressure development in oil film. Two-dimensional Reynolds equation, pressure distribution in journal bearings - long & short, Load Carrying capacity, Somerfield number, importance of radial clearance, eccentricity ratio minimum oil film thickness etc., Heat Balance equations. Fixed bearing design using Raymondi and Boyd concept. **Hydrodynamic Thrust Bearing** Introduction, flat plate thrust bearing, pressure distribution equation, load, centre of pressure. Tapered thrust bearing, Friction in thrust bearing, Heat Balance equations.	**08 L**
04.	**Hydrostatic Lubrication** Basic concept, operations, advantages and limitations. Flow of viscous fluid through rectangular slot, Circular pad bearing and conical bearing, load carrying capacity and flow of lubricants. Bearing power, energy losses in bearing and film thickness, bearing temperature. Rigidity of bearing design.	**08 L**

05. Elastohydrodynamic and Aerostatic Lubrication **06 L**

Principle and applications, Hertz Theory, Pressure viscosity term in Reynolds's equation, Ertel-Grubin equation. Introduction to Aerostatic Bearing and its application.

06. Hydrostatic Squeeze Film **06 L**

Introduction, parallel rectangular plate, Circular plate approaching each other and cylinder near plane, pressure distribution, squeeze load and time of approach.

TRIBOLOGY IN DESIGN AND MANUFACTURING LAB SYALLBUS:

Sr. No.	Title of Experiment	Duration
1	To Study the measurement of Friction and Wear using Pin-on disk Tribometer under static loading.	2 hrs
2	To Study the measurement of Friction and Wear using Pin-on disk Tribometer under dynamic loading.	2 hrs
3	To Study the measurement of Friction and Wear using dry bearing test rig Tribometer.	2 hrs
4	To Study the lubricant property using Four Ball tester	2 hrs
5	To Study the measurement of TAN and TBN of the Oil	2 hrs
6	To Study the measurement of Viscosity of the Oil	2 hrs
		12 hrs

Course outcomes:

1. Understand basic concept of tribology to evaluate friction and wear of materials.
2. Classify various types of lubricants to learn their applications.
3. Design hydrodynamic bearing under various load carrying capacity, power loss and heat balance in bearing.
4. Analyze performance of hydrostatics bearing by optimizing bearing parameters.
5. Understand basic principles of Elestohydrodynamics bearing and aerostatics bearing to know their applicability.
6. Apply fundamentals of Hydrostatics Squeeze film to solve problems on Squeeze load, time of approach etc.

Suggested learning resources:

Textbooks:

1. Basu S.K., Sengupta S. N. and Ahuja B.B. "Fundamentals of Tribology" PHI Learning, Ltd. India.
2. Majumdar B. C. "Introduction to Tribology and Bearings", S. Chand and Company Ltd., New Delhi.

Reference Book:

1. Bharat Bhushan, "Principles and Applications of Tribology", John Wiley and Sons.
2. Sahu P., "Engineering Tribology", PHI Learning, Ltd. India
3. Fuller D.D. "Theory and Practice of Lubrication for Engineers". John Wiley and Sons.
4. Neale M. J. "Tribology hand Book", Butterworths. London.
5. Orlov P., "Fundamentals of Machine Design", Vol. IV, MIR Publication.
6. Cameron A. "Basic Lubrication Theory", Wiley Eastern Ltd.
7. 'Hailing J., "Principles of Tribology", McMillan Press Ltd., 1975.
8. Ghosh M.K., Majumdar B.C. and Sarangi M., "Theory of lubrication", Tata McGraw Hill Education Pvt. Ltd., New Delhi.

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Course: MECHATRONICS

Course Code	MFG(PE)-25003	**Scheme of Evaluation**	Continuous Evaluation (CE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:
By the end of this course, students will be able to:

1. Understand the fundamentals of Mechatronics systems, their architecture, and their significance in modern manufacturing environments.
2. Develop an understanding of sensors, actuators, controllers, and their integration in automated systems.
3. Analyze and design basic control systems applicable in mechanical and manufacturing domains.
4. Explore interfacing technologies, including microcontrollers, PLCs, and HMIs for real-time control.
5. Apply Mechatronics principles to develop intelligent, automated systems for industrial and shop-floor applications.

Syllabus:

Unit	**Contents**	**Lecture**
01.	**Mechatronics:** Introduction to Mechatronics, Application areas of Mechatronics, Mechatronic Design Processes, Introduction to Measurement Systems, Control Systems System Response: Introduction, Input -Output model equation and system characterization, Instantaneous, Lagging and Delay Response, Transient Response Specification, Test Signals, Signals, Bandwidth and Frequency Response, Dynamic Characteristics of Measurement, Frequency Response of a System.	07L
02.	**Digital Logic**, Circuits, Systems and Hardware: Digital Logic, Boolean Algebra, Karnaugh Maps, Combinational Logic and Circuits, Timing Diagrams, Design of Logic Networks, Sequential Logic, Devices and Circuits, Integrated Circuit System Design. 21 **Microprocessors and Microcontrollers:** Introduction, Microprocessor-based Digital Control, Microprocessor Architecture, Memory, Input/Output Hardware, Microcontrollers, General Requirements for control and their implementation in Microcontrollers, Classifications, Applications.	07L
03.	**Input/Output Systems:** Interfacing, Input/Output Addressing, Interface Requirements, Peripheral Interface Adapters, Serial Communications Interface, Examples of Interfacing. Machine to machine to communication. (M2M)	07L
04.	**Sensors, Transducers and Actuators**: Introduction to Sensors and Transducers, Performance characteristics – static and dynamic, Sensor working Principles, Selection of sensors	07L

05. **Microcontrollers and Connectivity technologies:** Introduction to use of open-source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages; web and mobile phone apps. 07L

06. **Signal Conditioning and Signal Processing:** Signal conditioning, Digital Signals, Data Acquisition, Digital Signal Processing, Pulse modulation. Analog Signal Processing, Analog to Digital Conversion. **Data Acquisition:** Introduction, Elements of a Data Acquisition and Control System, Overview of the Input/Output Process, Analog to Digital (A/D) Conversion, Digital to Analog (D/A) Conversion, Data Acquisition Case Studies, Data Acquisition and Control Case Studies. 07L

MECHATRONICS LAB SYLLABUS:

List of Experiments: (Any Seven)

1. Study and Interfacing of Sensors (Inductive, Capacitive, IR, Ultrasonic)
2. Calibration and Operation of Linear and Rotary Encoders
3. Interfacing of Actuators (Solenoids, Relays, Stepper and Servo Motors)
4. PLC Programming for Bottle Filling or Pick-and-Place System
5. Simulation and Implementation of Conveyor Sorting System Using PLC
6. Data Acquisition and Analysis Using NI DAQ or Arduino-Based System
7. Closed-Loop Control of DC Motor (Speed/Position) Using PID Controller
8. Pneumatic and Electro-Pneumatic Control Circuit Design Using Simulation Tools (e.g., Fluid SIM)
9. Integration of HMI with PLC for Industrial Process Control
10. Condition Monitoring of Motors or Rotating Systems Using Vibration Sensors and FFT Analysis
11. Smart Assembly System Using Arduino and Sensors (e.g., smart nut tightening)
12. Force/Strain Measurement Using Strain Gauges on Mechanical Components
13. Temperature Monitoring and Control of Heating Element Using Thermocouple and Arduino/PID
14. Vision-Based Object Identification and Sorting Using Basic Image Processing (OpenCV/MATLAB)
15. Simulation of Automated Manufacturing Cell Using Digital Twin Software (e.g., Siemens Tecnomatix/Factory I/O)

Course Outcomes:

Upon successful completion of the theory component, the student will be able to:

1. Explain the structure, role, and applications of Mechatronics systems in modern manufacturing and automation environments.
2. Identify, select, and experimentally validate the working principles of sensors and actuators used in industrial Mechatronic systems.
3. Analyze, design, and implement basic analog and digital control circuits for Mechatronics applications.
4. Interface, program, and test PLCs and microcontroller-based systems for shop-floor automation and control tasks.
5. Develop, simulate, and integrate functional Mechatronics subsystems involving sensing, actuation, control, and data acquisition.
6. Diagnose, troubleshoot, and evaluate Mechatronic systems to propose effective solutions for practical manufacturing and automation problems.

Suggested learning resources:

Text Books

1. Appu Kuttan, Introduction to MECHATRONICS, Oxford Univ Press, 2010
2. Er R K Rajput, A Textbook of Mechatronics, S Chand Publishing, 2007

Reference Books

1. W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering, 2nd Edition, Addison Wesley Longman Ltd., 1999.
2. Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997
3. Bradley, D. Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products and Processes, Chapman and Hall, London, 1991.
4. Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
5. Wolfgang Gopel, Sensors- A comprehensive Survey Vol I & Vol VIII, VCH, Wiley
6. Hanocha H. (2012), Actuators – Basics and applications 3/e, Springer.

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Course: METAL FORMING TECHNOLOGY

Course Code	MFG(PE)-25004	**Scheme of Evaluation**	Continuous Evaluation (CE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- Understand the fundamental concepts of various metal forming processes and apply analytical methods to assess them.
- Apply theoretical principles to solve practical challenges in material forming processes such as rolling, drawing, forging, and extrusion.
- Develop a comprehensive understanding and appreciation of the scope and complexity of material forming.
- Grasp the fundamental aspects of formability and metalworking principles.
- Apply different yield criteria to solve metal forming problems effectively.
- Explore advanced metal forming processes and their applications.

Syllabus:

Unit	Contents	Lecture
01.	**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.	**08L**
02.	**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.	**06 L**
03.	**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	**06 L**

04.	**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	**06 L**
05.	**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.	**06 L**
06	**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.	**09 L**

MATERIAL FORMING TECHNOLOGY LABORATORY SYLLABUS: -

Exp. No	Contents	Practical (hours)
01.	Study of Flow Stress Determination in Metal Forming	02
02.	Verification of Von-Mises and Tresca Yield Criteria	02
03.	Study for Forging Slab Analysis	02
04.	Study of Wire Drawing: Effect of Die Angle and Lubrication	02
05.	Rolling Force Analysis and Thickness Reduction Study	04
06.	Extrusion Process Simulation and Die Design Optimization	02
07.	Formability limit curve evaluation for forging	04
08.	Effect of Lubrication on Metal Forming Processes	02
09.	High-Velocity Forming: Explosive and Magnetic Pulse Forming	02
10.	Study of Advanced forming processes & simulation	02

Course outcomes:

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

1. Learn basic concepts of different metal forming process and the application of concept to analyze 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 yield criterions to metal forming problems.
6. Learn about various advanced metal forming processes.

Suggested learning resources:

1. Dieter, Mechanical Metallurgy, ISBN0071004068
2. G.W. Rowe, “Principles of industrial metal working process”, Edward Arnold ISBN8123904282.
3. Chapman W.A.J, “Workshop Technology”, Volume I, II, III, CBS Publishers and distributors, 5th Edition,2002.
4. Degarmo, Black and Kohser, “Materials and processes in Manufacturing”, Prentice Hall of India. 2nd Edition, 1998.
5. Dr. R. Narayanswamy, Metal Forming Technology, Ahuja Book Co. ISBN8176190020
6. P.N. Rao, “Manufacturing Technology”, Tata Mc-GrawHill ISBN0070087695
7. S.K. Hajra Choudhary and S.K. Bose, “Elements of workshop Technology” Volume I, II, Asia Publishing House, 10th Edition 2000
8. ASM Metal handbook Vol: 14 Forming and Forging.
9. O.P. Khanna and M. Lal, “Production Technology”, Vol. I,II, Dhanpat Rai Publication, 5 th Edition, 1999.
10. B.S. Raghuwanshi, “Workshop Technology”, Dhanpatrai Publication, 9th Edition, 1999

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Course: ADDITIVE MANUFACTURING (AM)

Course Code	MFG(PE)-25005	**Scheme of Evaluation**	Continuous Evaluation (CE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0 = 5	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- Students will be able to gain fundamental and advanced knowledge in the field of Additive Manufacturing and its industrial applications associated with Manufacturing, Aerospace, Architecture, Biomedical, and Creative designing.
- Students will be skilled to analyze for adopting AM to make a product, or a part of the product, in comparison to the traditional method.
- Students will be able to critically analyze the requirement and produce an efficient part using optimized design, material and AM method.

Syllabus:

Unit	Contents	Lecture
01.	**Introduction to Additive Manufacturing (AM)** Introduction to AM, AM evolution, Distinction between AM and CNC machining, Advantages of AM, AM process chain; Conceptualization, CAD, conversion to STL, Transfer to AM, STL, AMF, AMF file formats, STL file manipulation, Machine setup, build, removal and clean up. Integration of Reverse Engineering and Rapid Prototyping. **Self-Study:** AMF, 3DF file formats	**08 L**
02.	**Classification of AM processes** VAT Photo-polymerisation (liquid photopolymer resin based); Material Jetting (Ink Jet, continuous or Drop on Demand) approach; Binder Jetting (Polymer or metal powder and liquid binder based); Material Extrusion (FDM, Metal, Ceramic extrusion based); Powder Bed Fusion (Metal, Polymer and Ceramic based DMLS, EBM, SLS, SLM); Sheet Lamination (Ultrasonic AM, laminated object manufacturing (LOM), Solid State AM); Directed Energy Deposition: DED (Laser engineered net shaping, directed light fabrication, direct metal deposition, 3D laser cladding) Special Types: WAAM, Jelly based, paper and Pulp **Self-Study:** Application of AM in Bio Medical field	**10 L**
03.	**Post processing of AM parts** Support material removal, strength improvement, stress relieving processes (Annealing, Normalising, HISP Furnace), surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques. Measurement of parts manufactured through AM process, Surface roughness measurement.	**06 L**

Unit	Contents	Lecture
	Self-Study: Comparison and analysis between various Post processing methods.	
04.	**Design for AM** Motivation, 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. Materials used in AM, Testing and standards for materials, Functionally Graded Materials (FGM). **Self-Study:** DFAM with Generative Design	**08 L**
05.	**Design and selection of machine components** Selection of components in assembly and construction of AM Machine - Axes, Linear motion guide ways, Ball screws, Motors, Bearings, Encoders/ Glass scales, Process Chamber, Safety interlocks, Sensors, Energy delivery, Material delivery, Nozzle and Heating Systems **Self-Study:** Standards in AM	**06 L**
06.	**AM Applications: Rapid Tooling** Convectional Tooling Vs. Rapid Tooling, Classification of Rapid Tooling, Direct and Indirect Tooling methods, Soft and Hard Tooling methods. Functional models, Pattern for investment and vacuum casting, medical models, art models, Engineering analysis models, new materials development, Bi-metallic parts, Re-manufacturing, maintenance and Hybrid AM. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries, Construction using AM. **Self-Study:** Part Customization using AM	**04L**

ADDITIVE MANUFACTURING (AM) LABORATORY SYLLABUS:

Sr. No.	Contents	Hours
01.	3D Printing Software : Introduction of 3D Printing Software, process parameters for Additive Manufacturing Technology (CURA, GRABCAD Print)	2
02.	Demonstration of STL editing and rectification software	2
03.	Demonstration and hands on experience on various additive manufacturing machines with suitable post processing techniques.	8
04.	Assembly of AM Machines – Assembly and Construction of FDM Technology 3D Printing Machine.	6
05.	3D Scanners- Introduction to Reverse Engineering and 3D Scanning, Types of 3D scanners - working principles, Setup and use of 3D scanners, 3D point cloud data collection and processing with the help of associated software Programme like Artec, David, etc., Application oriented case study.	8

Course outcomes:

The student will show their ability at a professional level to:

1. *Interpret and apply* digital manufacturing workflows by converting CAD models or Point cloud data obtained through reverse engineering techniques into appropriate AM file formats (STL, AMF, 3DF), performing file manipulation, and executing machine setup, build, and part removal operations.
2. *Classify and compare* various Additive Manufacturing processes, including vat photopolymerisation, material jetting, binder jetting, material extrusion, powder bed fusion, sheet lamination, and directed energy deposition, with respect to materials, working principles, and applications.
3. *Analyse and select* suitable post-processing techniques for AM parts to improve mechanical properties, dimensional accuracy, surface quality, and functional performance.
4. *Apply Design for Additive Manufacturing (DfAM) principles* to exploit design freedoms, optimize part orientation, minimize supports, reduce part count, and incorporate complex geometrical features.
5. *Design and justify* the selection of critical machine components and subsystems used in Additive Manufacturing equipment, considering functionality, safety, and process requirements.
6. *Assess and demonstrate* the application of Additive Manufacturing in rapid tooling, product customization, hybrid manufacturing, and industrial sectors such as aerospace, automotive, biomedical, construction, and general engineering.

Suggested learning resources:

Textbooks:

1. Chua Chee Kai, Leong Kah Fai, "Rapid Prototyping: Principles and Applications", World scientific, 2003.
2. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010
3. Ali K. Kamrani, Emand Abouel Nasr, "Rapid Prototyping: Theory and Practice", Springer, 2006.

Reference Books:

1. Paul C. Bave: CAD Principles and Applications
2. Understanding of Additive Manufacturing, Andreas Gebhardt, Hnaser Publishers, 2011.
3. D.T. Pham, S.S. Dimov, Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer 2001
4. Pulak Mohan Pandey, Nishant Kumar Singh, Yashvir Singh Additive Manufacturing: Advanced Materials and Design Techniques, CRC Press 2024

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Course: OPERATIONS RESEARCH (Open Elective-III)

Course Code	OEC25007	**Scheme of Evaluation**	**MSE, TA & ESE**
Teaching Plan	2-0-0-0 = 2	MSE- 30	TA- 20
Credits	2	ESE -50	

Course Objectives:

- To understand the methodology of OR problem solving and formulate linear programming problem.
- To develop formulation skills in transportation models and finding solutions
- To understand the basics in the field of game theory and assignment problems
- To know the basics of dynamic programming and simulation.
- To know how project management techniques help in planning and scheduling a project

Syllabus:

Unit	**Contents**	**Lecture**
01.	**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.	6 L
02.	**Transportation:** Introduction, methods for finding initial basic solution. Test of optimality Maximization Transportation problem. Degeneracy. **Assignment Problem:** Introduction. Solution methods. Variations of the assignment problem. Traveling Salesman Problem.	6 L
03.	**Sequencing Models:** Scheduling and sequencing. Assumptions in sequencing models. Processing "n" jobs on "m" machines. Graphical Method. **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.	7 L
04.	**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. **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.	7 L
05.	**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	7 L

completion of a project on before specified time, resource allocation and load smoothening, minimal Spanning tree, shortest route and maximal Flow problems.

Course outcomes:

1. Recognize the importance and value of Operations Research and linear programming in solving practical problems in industry.
2. Interpret the transportation models' solutions and infer solutions to the real-world problems.
3. recognize and solve game theory and assignment problems.
4. Know when simulation and dynamic programming can be applied in real world problems.
5. Gain knowledge of drawing project networks for quantitative analysis of projects.

Suggested learning resources:

Textbooks:

1. Gupta P. K. and Hira D. S.: Operations Research, S Chand & Company Ltd, Reprint 2022
2. Sharma S. D., Kedar Nath: Operations Research, Ram Nath& Co. Reprint 2024

Reference Book:

1. Schwartz M.M. “Metals Joining Manual”. McGraw Hill Books, 1979.
2. Tylecote R.F. “The Solid Phase Welding of Metals”. Edward Arnold Publishers Ltd. London, 1968.
3. Sharma J. K.: Mathematical Models in Operations Research, Tata McGraw – Hill Publishing Company Limited.
4. Taha H. A.: Operations Research - An Introduction, Prentice Hall of India Pvt. Ltd.
5. Wagner H. N.: Principles of Operations Research with applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd.
6. R. Panneerselvam: Operations Research, Prentice Hall of India Pvt. Ltd.
7. Wiest J. D. & Levy F. K.: Managerial Guide to PERT/CPM, Prentice Hall of India Pvt. Ltd.

NPTEL – Swayam

- https://onlinecourses.nptel.ac.in/noc25_mg34/course

Open Elective-III

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Wellesley Road, Chhatrapati Shivajinagar, Pune -411005.

Course: RELIABILITY ENGINEERING (Open Elective-III)

Course Code		**Scheme of Evaluation**	MSE,TA & ESE
Teaching Plan	2-0-0-0 = 2	**MSE** +TA	30 +20
Credits	2	**ESE**	50

Course Objectives:

- To understand basic concepts of Reliability
- To categorize the configuration and analyze the of system reliability.
- To identify failure modes and critical analysis through FMECA
- To apply reliability testing methods for life assessment

Syllabus:

Unit	Contents	Lecture
01.	**Fundamental concepts of Reliability** Reliability definitions, failure, failure density, failure Rate, hazard rate, Mean Time to Failure (MTTF), Mean Time Between Failure (MTBF), pdf, cdf, safety and reliability, life characteristic phases, modes of failure, areas of reliability, quality and reliability assurance rules, importance of reliability	**08 L**
02.	**System Reliability & Allocation Techniques** Series, parallel, mixed configuration, k- out of n structure, analysis of complex systems, conditional probability method, cut set and tie set method, Redundancy & Types, Reliability allocation or apportionment, reliability apportionment techniques - equal apportionment, AGREE, ARINC, reliability predictions from predicted unreliability, minimum effort method	**08 L**
03.	**Failure Analysis** Failure mode, effects analysis (FMEA), Failure mode, effects and criticality analysis (FMECA)-Case Studies, RPN, Basic symbols, Ishikawa diagram for failure representation, Fault Tree construction and analysis - case studies, minimal cut & tie set methods	**06 L**
04.	**Reliability Testing** Introduction to reliability testing, Stress strength interaction, Testing for Reliability and Durability- Accelerated Life Testing and Highly Accelerated Life Testing (HALT)	**06 L**

Course outcomes:

1. Understand basic concepts of reliability
2. Analyze reliability of system and apply allocation methods.
3. Identify various failures and failure modes and to create a FMEA & fault tree diagram.
4. Evaluate system reliability through reliability tests

Suggested learning resources:

1. L. S. Srinath, Reliability Engineering, EWP , 4th Edition 2016
2. E. Balgurusamy, Reliability Engineering, McGraw Hill Education 2002
3. S. S. Rao, Reliability Based Design, Mc Graw Hill Inc. 1992
4. E. E. Lewis, Introduction to Reliability Engineering, John Wiley and Sons.2022
5. Alessandro Birolini, Reliability Engineering Theory and Practice, Springer,2017
6. B. S. Dhillon, Maintainability, Maintenance and Reliability for Engineers, CRC press 2020.
7. K. C. Kapoor and L. R. Lubersome, Reliability in Engineering Design Willey Publication, 2014
8. Basu S.K, Bhaduri , Terotechnology and Reliability Engineering, Asian Books Publication.2003

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Course: Multi-Disciplinary Minor course
MATERIALS MANAGEMENT

Course Code		**Scheme of Evaluation**	MSE, TA & ESE
Teaching Plan	3-1-0-0 = 4	**MSE- 30**	TA- 20
Credits	4	ESE -50	

Course Objectives:

The Materials Management syllabus aims to equip students with

- Comprehensive understanding of Materials Management, its scope, aims, objectives, and the importance of an integrated approach in manufacturing and service organizations.
- Inventory control techniques such as ABC analysis and EOQ, and to understand procurement lifecycle, material types, MRP run, and Bill of Materials (BOM).
- Familiarize students with the Enterprise Structure and Master data in MM
- P2P Cycle, purchase information record, procurement of stock and consumable material
- Knowledge of inventory management, covering stock types, goods movements, reservations, stock transfers
- Business processes in MM, logistics invoice verification, three-way match.

Syllabus:

Unit	Contents	Hrs
01	**Introduction to Materials Management:** Introduction to Materials Management: An overview – Introduction – Scope, Aim of Material Management, Objective, Importance of Integrated approach to Materials Management	8L
02	**Materials Planning:** Inventory control, ABC analysis, Economic Order Quantity, Lifecycle of Procurement, Types of Material and Procurement, MRP RUN, BOM	8L
03	**Master Data:** Basic Features of MM module in ERP systems: Terms used in MM module, MM Organizational Structure, Material master data, Vendor master data	10L
04	**Sourcing and Procurement:** Purchase information record, Sources of supply, MM Processes: Procure-to-Pay Process, Business Processes in MM, Procurement of Stock Material, Procurement of Consumable material	10L
05	**Inventory Management:** Stock types, special stocks, Vendor Return, Good Receipts, Stock Transfer and Transfer Posting, Reservations, Goods Issue, Negative stock	8L
06	**Special Procurement:** Logistics Invoice Verification, 3-way match, Invoice Entry, Web ERP Concept, Subcontracting, Vendor Consignment, Contracts, Third party procurement	12L
	Total	56L

Course outcomes:

The student will show their ability at a professional level to:

1. Explain the concept, scope, objectives, and importance of Materials Management**,** emphasizing the role of an integrated approach in organizational efficiency.
2. Apply inventory control techniques such as ABC analysis and EOQ, and analyze procurement lifecycle, material types, MRP run, and Bill of Materials (BOM) for effective material planning.
3. Demonstrate an understanding of ERP MM module fundamentals, including MM terminology, organizational structure, material master data, and vendor master data.
4. Execute and analyze procurement processes in ERP systems, including source determination, purchase information records, procure-to-pay cycle, and procurement of stock and consumable materials.
5. Manage inventory and stock transactions in ERP by applying concepts of stock types, special stocks, goods receipt and issue, reservations, stock transfer, vendor returns, and negative stock handling.
6. Apply advanced MM and logistics processes such as logistics invoice verification, three-way matching, and learn about special procurement like subcontracting, vendor consignment.

Suggested learning resources:

Textbooks:

1. Gopalakrishnan, P. and Sundaresan, M**.** *Materials Management: An Integrated Approach* Prentice Hall of India (PHI), New Delhi.
2. Arnold, J.R. Tony, Chapman, S.N., and Clive, L.M. *Introduction to Materials Management*

Reference Books:

1. Harris, F.W. *Operations and Materials Management* Tata McGraw-Hill.
2. Kumar, S. and Suresh, N. *Production and Operations Management* New Age International.
3. Vollmann, T.E., Berry, W.L., Whybark, D.C., Jacobs, F.R. *Manufacturing Planning and Control for Supply Chain Management* McGraw-Hill.
4. SAP Press (Latest Edition) *Materials Management with SAP ERP (MM)* SAP Press. *(For ERP-oriented institutions)*

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PROJECT-I (Semester-V)

Course Code	MFG-25005	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-4-0 = 4	**CIE**	100
Credits	2		

Sr No	Items	Description of activity
1	**Scope** **(TRL-2)**	Research Problem Identification, Literature, objective, methodology and Architecture / Plan of work
2	**Student project group**	Four students maximum per project. The student group remained the same till the completion of the three stages of the project. No change in topic / group / guide is allowed in subsequent stages of projects. In case of eventuality, alternate guide may be allotted.
3	**Problem statement identification**	It is mandatory for faculty members to float projects with carefully selected problem statements well in advance. The project should be floated and allotted within a week after the 5th semester registration process is over. Since the project will run for one and half years, it is required by the department to float topics for the choice of students. The project topic should be in line with National Mission / Atmanir bharbharat / Industry requirements/ Funding body requirements / socially relevant project / Sustainable Development Goals (SDGs)
4	**Project topic selection**	The student group shall choose a project topic amongst the available topics given by the department based on the previous semester CGPA.
5	**Self-Study material for the student**	The department should recommend relevant online / offline self-study materials on IPR, technical paper writing, plagiarism, safety, NDA, Regulatory standards, for example- BIS, etc.
6	**End Semester Evaluation process**	The end semester evaluation shall be based on project power point presentation and well-structured project report. The evaluation shall be done by the panel of at least three members including one of them is project guide.

Evaluation sheet for Project-I

MIS No	Name of student	Research problem identification	Literature	Objective	Project Report	Viva Voce and presentation skill	Out of 50 marks
		10 M	**10 M**	**10 M**	**10M**	**10M**	

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INTERNSHIP-II

Course Code	MFG-25006	**Scheme of Evaluation**	CIE
Teaching Plan		**CIE**	100
Credits	1		

- Summer Internship–II shall be undertaken by students after completion of the IVth semester during the summer vacation, in an Industry, R&D organization, or Academic/Research Institute (HEI less than 100 NIRF rank).
- This internship is designed to enhance practical competencies, problem-solving ability, research orientation, professional ethics, teamwork, and communication skills, thereby strengthening industry–academia linkage.
- The minimum duration of the internship shall be four weeks (one month) and the maximum duration shall be eight weeks (two months).
- The evaluation of Summer Internship–II will be conducted at the beginning of the Vth semester, based on the internship report, presentation, and assessment by the assigned faculty committee, ensuring effective learning outcomes and skill development.

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Semester VI

Course: ADVANCES IN CAD/CAM/CIM

Course Code	MFG-25007	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	2-1-2-1	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:
Advances in CAD/CAM/CIM Course aspires to provide students with the ability of

- Understanding the basic fundamentals of computer aided design and to learn 2D & 3D transformations of the basic geometrical entities along with their representation using parametric and solid representation techniques.
- Obtaining an understanding of the fundamental theory of the FEA method and demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes
- Learning the concepts of computer aided manufacturing, classification of NC machines based and use of G and M codes to develop part programmes.
- Providing exposure of various concepts of CIM, Computer Aided Inspection, CAPP & ERP.
- understanding concepts of Group Technology & its utilization leads to formation of machines cell

Syllabus:

Unit	Contents	Hrs
01	**Introduction to CAD-CAM** Introduction: Trends in Modern Manufacturing, Product Cycle and CAD/CAM, Functional relationship, Elements of CAD Hardware. Computer Graphics: Transformation- Introduction, Formulation, Translation, Rotation, Scaling, Reflection, Homogenous Representation, Concatenated Transformation, Inverse Transformations. **Self Study:** Elements of CAD Hardware	4L
02	**Solid Modelling Representation Techniques:** Solids:- Introduction, Geometry & Topology, Solid Representation, Boundary Representation, Constructive Solid Geometry, Sweeps, Solid Manipulations, Feature Based Modelling, Cloud Based Solid Modelling Techniques **Self Study:** Types of Primitive solid geometries and its developments in solid modelling	5L
03	**Surface Modelling Techniques:** **Curves:-** Introduction, Analytic Curves, Parametric representation, Line, Circle, Parabolas, Hyperbolas, Ellipses, Conics. Geometric continuity (C0, C1, C2) and Visual continuity (G0, G1, G2), Synthetic Curves, Hermite Cubic Spline, Bezier Curve, B-Spline Curve and NURB **Surface:** - Introduction, Surface Representation, Analytic Surface, Synthetic Surfaces, Hermite bicubic Surface, Bezier surfaces, B-spline Surfaces, Coons Surface, Reverse Engineering, Computer aided inspection and quality control **Self Study:** Types of Curves and surfaces, it's applications in Surface Modeling	5L

04 Finite Element Analysis

Introduction to FEA, Advantages & Disadvantages of FEA & its applications, what is FEA, Functional Approximation method, Finite Difference Method, Steps involved in FEA, Stiffness matrix & its properties, Derivation of Stiffness matrix, Types of Elements. 5L

Self Study: Advantages & Disadvantages of FEA & its applications

05 NC Programming

Machine Tool Co-ordinate System, Machine zero, Job zero, Cutter Programming, Tool Offsets, Programming Steps, NC Programming Languages, G-codes and M-codes. Turning Center programming, Machining Center programming, Advance features of Controller. 4L

Self Study: Machine zero-Job zero

06 Computer Integrated Manufacturing (CIM)

Computer application in manufacturing, Computer integrated production management system, inventory material requirement planning, manufacturing resource planning, enterprise resource planning. Computer aided process planning (CAPP): Retrieval CAPP, generative CAPP and computer assisted shop floor control. 4L

Introduction to PLM

Self Study: enterprise resource planning application in manufacturing

07 Group Technology

Part Families, Part classification and coding, production flow analysis, Rank Order Clustering Algorithm, machine cell design and Cellular manufacturing 3L

Self Study: Applications of Group Technology

Total 30L

Sr. No.	List of Tutorials	Hrs
01	Tutorial 1- Numerical on Transformation Matrices	2 L
02	Tutorial - Numerical on Solid representation Schemes	2 L
03	Tutorial - Numerical on curve Representation techniques	2 L
04	Tutorial - Numerical on Finite Element Analysis	2 L
05	Tutorial - Numerical on G-M Code programming	2 L
05	Tutorial - Numerical on Group technology and Rank order Method	1 L
06	Tutorial - Numerical on MRP	1 L
	Total	**12 L**

Sr. No.	List of Assignments	Hrs
01	Introduction to CAD Software - Part Design	2 L
02	Introduction to CAD Software - Assembly Design	2 L
03	Introduction to CAD Software - Drafting	2 L
04	Introduction to CAE - Finite Element Analysis and ANSYS Software	2 L
05	FEA Assignment: Simply Supported Beam, Cantilever Beam	2 L
06	FEA Assignment: Chair Problem	2 L
07	FEA Assignment: Workbench Overview	2 L
08	CAM Assignment : Turning Programming	2 L
09	CAM Assignment : Milling Programming	2 L
	Total	**18 L**

Course outcomes:

The student will show their ability at a professional level to:

1. Solve the problems based on transformations of geometrical entities and develop its representation in a CAD system to validate the results.
2. Represent the mathematical expression of geometrical entities to Evaluate and Validate developed curves, surfaces, and solids.
3. Learn the concept of FEA and its implementation to Evaluate and analyse FEA results for component design.
4. Explain and Classify NC machines and its working principles to Develop NC programs using manual part programming techniques.
5. Discuss the various concepts of CIM such as production planning and control, process planning, MRP, and ERP to Solve the problems based on MRP during its implementation in large scale manufacturing.
6. Explain the Group technology to Apply the concepts of production flow analysis and rank order clustering to Formulate machine cells

Suggested learning resources:

Textbooks:

1. Mikel P. Groover and Emory W. Zimmers: Computer Aided Design and Manufacturing, Prentice Hall.
2. T. Kundra, Rao P.M., Tiwari N.K. : Numerical Control and Computer Aided Manufacturing, Tata McGraw Hill

Reference Books:

1. Nanua Singh: Systems Approach to Computer-Integrated Design and Manufacturing, John Wiley and Sons, Inc.
2. P. Radhakrishnan and Subramaniam: CAD / CAM / CIM, Wiley Eastern Ltd.
3. Venuvinod, PK., MA. W., Rapid Prortotyping – Laser Based and Other Technologies, Kluwer, 2004. Paul C. Bave: CAD Principles and Applications
4. Mikell P. Groover: Automation, Production systems & Computer Integrated Manufacturing, Prentice Hall.
5. Ibrahim Zeid: Mastering in CAD-CAM, Tata McGraw Hill Publication.

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Course: OPERATIONS RESEARCH

Course Code	MFG-25008	**Scheme of Evaluation**	**MSE, TA & ESE**
Teaching Plan	3-0-0-1 = 4	MSE- 30	TA- 20
Credits	3	ESE -50	

Course Objectives:

- To understand the methodology of OR problem solving and formulate linear programming problem.
- To develop formulation skills in transportation models and finding solutions
- To understand the basics in the field of game theory and assignment problems
- To know the basics of dynamic programming and simulation.
- To know how project management techniques help in planning and scheduling a project

Syllabus:

Unit	Contents	Lecture
01.	**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. Self Study: Numerical on Big M/Two-phase method.	6 L
02.	**Transportation:** Introduction, methods for finding initial basic solution. Test of optimality Maximization Transportation problem. Degeneracy, Tran-shipment problem. **Assignment Problem:** Introduction. Solution methods. Variations of the assignment problem. Traveling Salesman Problem. Self Study: Numerical on Transhipment problems.	6 L
03.	**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. Self Study: Price Break Curve	7 L
04.	**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.	7 L

Dynamic Programming: Distinguishing characteristics of D.P.
Deterministic DP problems.
Self Study: Numerical on Dynamic Programming

05.	**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. Self Study: Numerical on Game theory using LPP	7 L
06.	**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. Self Study: Numerical on Minimum Spanning Tree	7 L

Course outcomes:

1. Recognize the importance and value of Operations Research and linear programming in solving practical problems in industry.
2. Interpret the transportation models' solutions and infer solutions to the real-world problems.
3. Recognize and solve game theory and assignment problems.
4. Know when simulation and dynamic programming can be applied in real world problems.
5. Gain knowledge of drawing project networks for quantitative analysis of projects.

Suggested learning resources:
Textbooks:

1. Gupta P. K. and Hira D. S.: Operations Research, S Chand & Company Ltd., Reprint 2022
2. Sharma S. D., Kedar Nath: Operations Research, Ram Nath& Co., Reprint 2024.

Reference Book:

1. Schwartz M.M. “Metals Joining Manual”. McGraw Hill Books, 1979.
2. Tylecote R.F. “The Solid Phase Welding of Metals”. Edward Arnold Publishers Ltd. London, 1968.
3. Sharma J. K.: Mathematical Models in Operations Research, Tata McGraw – Hill Publishing Company Limited.
4. Taha H. A.: Operations Research - An Introduction, Prentice Hall of India Pvt. Ltd.
5. Wagner H. N.: Principles of Operations Research with applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd.
6. R. Panneerselvam: Operations Research, Prentice Hall of India Pvt. Ltd.
7. Wiest J. D. & Levy F. K.: Managerial Guide to PERT/CPM, Prentice Hall of India Pvt. Ltd.

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Course: MANUFACTURING AUTOMATION

Course Code	MFG-25009	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-1	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- To introduce students to the fundamentals of manufacturing systems and automation
- To provide an understanding of different automation technologies used in modern manufacturing.
- To explore the applications of sensors, actuators, and control systems in industrial automation.
- To develop problem-solving skills for implementing automation solutions in real-world manufacturing environments.
- To explore industrial control systems and hardware components used in automation.

Syllabus:

Unit	Contents	Lecture
01.	**Introduction to Manufacturing Systems and Manufacturing Automation** :Overview of Manufacturing Systems and Their Evolution, Types of Manufacturing Systems: Job Shop, Batch, Mass, and Continuous Production, Fundamentals of Manufacturing Automation, Types of Automation: Fixed, Programmable, and Flexible, Automation Strategies in Manufacturing, Benefits and Limitations of Automation in Manufacturing, Industry 4.0 and Smart Manufacturing, Role of Artificial Intelligence and Industry 4.0 in Automation. **Self-Learning Topics:** Historical Evolution of Automation in Manufacturing, Case Studies on Automated vs. Traditional Manufacturing, Historical Development of Automation Technologies, Case Studies on Automation in Different Industries	07 L
02.	**Automated Material Handling and Storage Systems:** Functions and Types of Automated Material Handling Systems (AMHS), Automated Guided Vehicles (AGVs) and Autonomous Mobile Robots (AMRs), Automated Storage and Retrieval Systems (AS/RS), Conveyor Systems and Robotics in Material Handling **Self-Learning Topics:** Recent Advances in AGVs and AMRs, Case Studies on Smart Warehousing	07 L
03.	**Sensors, Actuators, and Control Systems in Automation:**, • Types of Sensors: Proximity, Vision, Force, and Temperature Sensors, Actuators: Hydraulic, Pneumatic, and Electric Drives, Programmable Logic Controllers (PLCs): Architecture and Programming, Supervisory Control and Data Acquisition (SCADA) Systems	07 L

Self-Learning Topics:
Smart Sensors and IoT in Manufacturing, Case Studies on Automated Quality Control

04. **Single Station Manufacturing Cells:** • Fundamentals of Single Station Manufacturing Cells, Machine Cell and Machine Cluster, Manual, Automated, and Semi-Automated Workstations, Machine Tool Automation and CNC Systems, Process Optimization in Single Station Cells — 07 L

Self-Learning Topics:
Advances in CNC and Adaptive Control Systems, Case Studies on Automated Machining Cells

05. **Manual Assembly Lines – Single Model:** — 07 L
Introduction to Manual Assembly Lines and Their Importance, Line Balancing Problems and Methods (Largest Candidate Rule, Kilbridge & Wester Method, Rank Positional Weight Method), Single Model, Poka-Yoke: Motion step Method.

Self-Learning Topics:
Lean Manufacturing and its Impact on Assembly Line, Case Studies on Assembly Line Improvements

06. **Automated Production Lines and Assembly Systems:** • Structure and Working of Automated Production Lines, Transfer Mechanisms: Linear and Rotary Transfer Lines, Control Strategies in Automated Production Systems, Buffering and Accumulation in Production Lines, Types of Automated Assembly Systems, Part Feeding and Orientation Techniques, Design for Automated Assembly (DFA) Principles, Performance Analysis and Economic Justification of Automated Assembly. — 07 L

Self-Learning Topics:
Case Studies on Successful Implementation of Automated Production Lines, Simulation and Optimization of Automated Production, Advances in Automated Micro-Assembly Systems, Case Studies on DFA and Assembly Line Automation

List of Experiments: (Any seven)
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 Programmable Logic Controllers (PLC).
5. Study of Displacement, Level, Pressure controls.
6. Measurements & Design of circuit for Speed & Temperature measurements.
7. Study & Design of Simple Hydraulic or Pneumatic and Electro-Hydraulic or Electro Pneumatic Automatic Control Circuit Problem.
8. Study & Design of Electro-hydraulic or Electro-pneumatic Control Circuit Problem.
9. Study of Maintenance and Troubleshooting of Fluid Power Systems.
10. Study/Demonstration of Electric actuators equivalent to hydraulic and pneumatic actuators.

Course outcomes:

After successful completion of this course, students will be able to:

1. Understand the principles of manufacturing automation and its significance in industry.
2. Analyze different types of manufacturing systems and automation strategies.
3. Analyze different types of automated material handling and storage systems.
4. Evaluate the role of sensors, actuators, and control systems in automation.
5. Analyze the design and operation of single station manufacturing cells.
6. Apply assembly line balancing techniques to optimize manual assembly lines.
7. Evaluate the functioning of automated production lines and their control strategies.

Suggested learning resources:

Textbooks:

1. Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Addison Wesley; 5th edition,2020, Prentice-Hall of India Private Limited.
2. W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering,6th Edition 2022 Pearson Education Limited.
3. Frank Lamb, Industrial Automation: Hands On, Tata McGraw Hill.

Reference Book:

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

NPTEL Course:

"Manufacturing Automation" by Prof. Sonak Choudhary.

"Automation in Manufacturing", by Prof. Shrikrishna Joshi

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Programme Elective Courses (PEC-2) - SEMESTER-VI

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	PEC 2	Design For Manufacturing and Assembly	3	0	2	0	5	4
2	PEC 2	Micro & Nano manufacturing	3	0	2	0	5	4
3	PEC 2	Advanced Joining Techniques	3	0	2	0	5	4
4	PEC 2	AI for Manufacturing	3	0	2	0	5	4
5	PEC 2	Fundamentals of Quantitative Techniques in Project Management	3	0	2	0	5	4

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Course: DESIGN FOR MANUFACTURING AND ASSEMBLY

Course Code	MFG(PE)-25006	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- To Learn need of design for manufacturability.
- To Understand the influence of manufacturing processes on product design .
- To explore environmental aspects on design and manufacturing.
- To evaluate impact of assembly parameters on design and manufacturability.

Unit No.	Details	Lecture
1	**Introduction:** General design principles for manufacturability: strength and mechanical factors, mechanisms selection, evaluation method, Process capability: Feature tolerances, Geometric tolerances, Assembly limits, Datum features, and Tolerance stacks.	6 L
2	**Factors Influencing form Design:** Working principle, Material, Manufacture, Design- Possible solutions, Materials choice, Influence of materials on form design, form design of Welded members, forgings and castings.	6 L
3	**Component Design-I:** Machining Consideration: Design features to facilitate machining: drills, milling cutters, keyways, Doweling procedures, counter sunk screws, Reduction of machined area, simplification by separation, simplification by amalgamation, Design for machinability, Design for economy, Design for clampability, Design for accessibility, Design for assembly.	8 L
4	**Component Design-II:** Casting Consideration: Redesign of castings based on parting line considerations, Minimizing core requirements, machined holes, redesign of cast members to obviate cores. Identification of uneconomical design, Modifying the design, group technology, Computer Applications for DFMA	6 L
5	**Design for the Environment:** Introduction, Environmental objectives, Global issues, Regional and local issues, Basic DFE methods, Design guide lines, Example application, Lifecycle assessment, Basic method, Environmentally	8 L

	responsible product assessment, Weighted sum assessment method, Lifecycle assessment method, Techniques to reduce environmental impact, Design to minimize material usage, Design for disassembly, Design for recyclability, Design for remanufacture, Design for energy efficiency, Design to regulations and standards	
6	**Design for Assembly**	6 L
	Introduction to Assembly: The assembly process, Characteristics and applications, Example of common assembly, Economic significance of assembly, General taxonomies of assembly operation and systems, Assembling a product, Design for Assembly: Introduction, Design consideration, Design for Fasteners: Introduction, Design recommendation for fasteners.	

DESIGN FOR MANUFACTURING AND ASSEMBLY-LABORATORY SYLLABUS

List of Practical (Any six):

1. Study and report on design principles for manufacturability
2. Study and report Influencing factors on Design.
3. Case study on Machining consideration
4. Case study on casting consideration
5. Case study on Life cycle assessment of product.
6. Case study on Assembly Aspects of Product.
7. Case study on design for environment

Course Outcomes:

At the end of the course, students will:

1. Learn how to modify or develop product design for ease of manufacture, considering advantages and limitations of various manufacturing processes.
2. Students can identify difficulties in manual and automated assembly of product and make changes in product design to minimize assembly difficulties by making the product design assembly friendly.
3. Exposed to strengths and weaknesses of various metal manufacturing processes so as to modify the product design and make necessary changes for suitable process.
4. Students can learn concept for design for environment

Text Books & Reference Books:

1	Kevien Otto and Kristin Wood, Product Design. Pearson Publication, 2004.
2	Product design and development, by K.T. Ulrich and S.D. Eppinger, Tata McGraw Hill
3	Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
4	Bralla, Design for Manufacture handbook, McGraw Hill, 1999.
5	Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
6	Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
7	Fixel, J. Design for the Environment McGraw Hill., 1996. 8. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub.1996.

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Course: MICRO & NANO MANUFACTURING (MNM)

Course Code	MFG(PE)-25007	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- Understand the fundamental concepts, principles, and technologies associated with micro/nano manufacturing.
- Analyze the principles, processes, and applications of advanced micro-machining methods.
- Evaluate various nano-machining and finishing processes in terms of applicability, precision, and effectiveness.
- Apply micro-scale manufacturing techniques to design and produce miniaturized components for specific engineering applications.
- Design and develop micro sensors, actuators, integrating micro-manufacturing concepts to create functional microsystems for real-world applications.
- Evaluate biomedical applications of micro and nano manufacturing by assessing their performance, reliability, and impact on healthcare innovation.

Syllabus:

Unit	Contents	Hrs.
01.	**Fundamental of micro and nano technology** • Micro and Nanofabrication. • Concepts of Micro and Nano-Systems and Microsystems Products. • Microsystems and Microelectronics, Application of Microsystems. • Standardization and Commercialization Issues of Micro-Nano Systems.	6 hrs.
02.	**Micro Machining** • Ultra Sonic Micro Machining, Abrasive Water Jet 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).	8 hrs.
03.	**Concepts of Micro Forming and Welding, and Micro Extrusion**	7 hrs.

- Micro and Nano structured surface development by Nano plastic forming, Roller Imprinting.
- Micro bending and micro welding with LASER.
- Electron beam for micro welding.
- Metrology for micro machined components.

04. Nano Machining and Finishing 8 hrs.

- 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.

05. Micro Sensors, Micro Actuation 6 hrs.

- MEMS with Micro actuators, Micro fluidics.
- Micro/nano sensors: 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.

06. Synthesis and Characterization of Nano materials 7 hrs.

- Sol-Gel Synthesis, Inert Gas Condensation, High energy Ball Milling, Plasma Synthesis
- Synthesis of Carbon nano tubes
- **Microscopy techniques**: scanning electron microscopy, transmission electron microscopy, scanning tunneling microscopy, atomic force microscopy

MICRO & NANO MANUFACTURING (MNM) LAB SYLLABUS:

Labs	List of Experiments	Hrs.
01	Demonstration of micro turning	4 hrs.
02	Fabrication of micro holes and slots using Micro-EDM	4 hrs.
03	Fabrication of micro holes using Micro-ECM	4 hrs.
04	Laser Beam micromachining of micro features	4 hrs.
05	Hybrid micromachining	4 hrs.
06	Microscopy and vision system analysis of machined microfeatures	4 hrs.
	Total	**24 hrs.**

Course outcomes:

At the end of the course, students will be

1. Explain the fundamental principles and key technologies involved in micro- and nano-scale fabrication processes, microsystems, and their applications.
2. Compare and analyze various micro-machining methods based on process capabilities, limitations, and applications.
3. Select and justify suitable nano-finishing techniques based on precision requirements and material considerations.

4. Demonstrate an understanding of micro forming, micro welding, and micro extrusion to design, develop, and fabricate miniaturized components for industrial applications.
5. Evaluate and discuss integration of micro sensors and actuators, microfluidic devices, bio-sensors and demonstrate an understanding of micro-manufacturing techniques and functional requirements.
6. Understand and apply techniques for the synthesis and characterization of nanomaterials, utilizing microscopy methods to evaluate material properties and structures.

Suggested learning resources:

Textbooks:

1. Chang Liu (2011), Foundations of MEMS 2/e, Prentice Hall.
2. Jain V. K. (2011), Introduction to Micro Machining, Narosa Publishing House.
3. Murty B. S. (2013), Textbook of Nanoscience and Nanotechnology, Springer-Universities Press India.

Reference Books:

1. Bhattacharyya B. (2015), Electrochemical Micromachining for Nanofabrication, MEMS and Nanotechnology, William Andrew Publications (Imprint by Elsevier).
2. Bandopadhyay A. K. (2008), Nano Materials, New Age International Publishers (New Delhi).
3. Tai-Ran Hsu (2008), MEMS and Microsystems, John Wiley & Sons (New Jersey).
4. Jackson, M. J. (2007), Micro and Nano Manufacturing, Springer.
5. Bharat Bhushan (2010), Handbook of Nanotechnology, Springer.
6. Fahrner W. R. (2008), Nanotechnology and Nano Electronics, Springer International.
7. Senturia S. D. (2000), Micro-Systems Design, Springer.
8. Hanocha H. (2012), Actuators – Basics and applications 3/e, Springer.

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Course: ADVANCED JOINING TECHNOLOGY

Course Code	MFG(PE)-25008	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- To impart knowledge of joining processes and their application
- To understand the various special/advanced welding processes
- Apply proper welding process for an industrial application
- To have practical overview of various welding process, welding standards, advanced welding process
- To gain knowledge on the principle of operation, advantages, limitations and applications of various special/advanced welding processes.

Syllabus:

Unit	Contents	Lecture
01.	**Fundamentals of Welding and Joining:** Physics of welding, Classification of welding processes, Brief review of conventional welding processes, Fundamental principles – Air Acetylene welding, Oxyacetylene welding, Carbon arc welding, Shielded Metal Arc welding (SMAW), Submerged Arc welding (SAW), TIG & MIG welding, Plasma Arc welding (PAW), Electroslag welding processes - advantages, limitations, and applications.	7 L
02.	**Resistance Welding Processes:** Principle of Resistance welding, Spot welding, Seam welding, Projection welding, Resistance Butt welding, Flash Butt welding, Percussion welding and High Frequency Resistance Welding processes - advantages, limitations and applications.	7 L
03.	**Solid State Welding Processes:** Cold Pressure welding, Diffusion Bonding, Explosive Welding, Ultrasonic Welding, Friction welding and its classification, Forge welding, Roll welding, Hot pressure welding processes - advantages, limitations and applications, Advances in adhesive bonding, Brazing and soldering, cladding.	7 L
04.	**Advanced Welding Processes:** Thermit welding, Atomic Hydrogen welding, Electron Beam welding, Laser Beam welding - principle, working and applications, Friction Stir Welding, Friction Stir Spot 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. Welding of Non-	7 L

metals: Plastic welding, Glass and ceramic welding, Biocompatible plastic to metal welding, Types of plastic welding

05. **Testing and Design of Weldments:** Design and quality control of welds. Edge preparation types of joints, weld symbols 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. 6 L

06. **Weld Metallurgy:** Weld thermal cycles and their effects, concept of weldability and its assessment. Heat affected Zone (HAZ) and its characteristics, Welding of dissimilar materials, pre and post welding heat treatments, welding defects, their causes and remedies. 6 L

ADVANCED JOINING TECHNOLOGY LAB SYLLABUS

List of Experiments: (Any eight)

1. Get acquainted with basic welding terms and welding symbols
2. Perform welding of Mild steel Plates by Gas Metal Arc Welding process. (GMAW)
3. Perform welding on of Mild steel/Stainless steel /Aluminium sheets by Gas Tungsten Arc Welding (GTAW)
4. Perform welding on Mild steel/Stainless steel sheets using Resistance Spot Welding for overlapping sheets
5. Perform welding on Aluminum sheets using Friction Stir welding and Friction Stir Spot welding (FSW/FSSW)
6. Perform welding using Mild steel/Stainless steel Laser Beam Welding (LBW)
7. Assessment of Mechanical Testing of weld specimen (Tensile test/bend test etc)
8. Assessment of welded joints using metallurgical tests (micro-structure and hardness variation).
9. Assessment of weld specimens using Non-Destructive Tests

Course outcomes:

1. Acquire knowledge of various conventional welding processes.
2. Explore the fundamentals and working of advanced Welding Processes.
3. Apply the knowledge to select the appropriate welding process based on application, customer requirement and specifications.
4. Analyze the weld metallurgy in a weld joint.
5. Evaluate a weld joint by inspection and testing of welded components
6. Suggest an appropriate measure or method to obtain a defect free weld.

Suggested learning resources:

Textbooks:

1. Parmer R.S., “Welding Engineering and Technology”, Khanna Publishers, New Delhi, 2022.
2. Little R.L., “Welding and Welding Technology”, Tata McGraw Hill Publishing Co., Ltd., New Delhi, 34th reprint, 2008.
3. Kalpakjian S., "Manufacturing Engineering and Technology" Prentice Hall Pearson Education India; 8th edition, 2023.
4. J.F.Lancaster, “ The Physics of welding”, Pergamon, 2nd edition, 1986
5. J.A.Goldak, “ Computational Welding Mechanics”, Springer, 2005

Reference Book:

1. Schwartz M.M. “Metals Joining Manual”. McGraw Hill Books, 1979.
2. Tylecote R.F. “The Solid Phase Welding of Metals”. Edward Arnold Publishers Ltd. London, 1968.
3. AWS- Welding Hand Book. 8th Edition. Vol- 2. “Welding Process”
4. Nadkarni S.V. “Modern Arc Welding Technology”, 1st edition, Oxford IBH Publishers, 2005.
5. Christopher Davis. “Laser Welding- Practical Guide”. Jaico Publishing House, 1994.
6. Davis A.C., “The Science and Practice of Welding”, Cambridge University Press, Cambridge, 1993.
7. Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM,2007.

NPTEL – Swayam

- https://onlinecourses.nptel.ac.in/noc21_mm01/preview
- https://archive.nptel.ac.in/courses/112/103/112103263/
- https://onlinecourses.nptel.ac.in/noc20_me65/preview

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Course: ARTIFICIAL INTELLIGENCE IN MANUFACTURING

Course Code	MFG(PE)-25009	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- To introduce students to the fundamentals of Artificial Intelligence (AI) and its applications in manufacturing.
- To familiarize students with AI techniques such as Machine Learning, Expert Systems, and Computer Vision for industrial applications.
- To explore the use of AI in process optimization, predictive maintenance, and quality control.
- To provide an understanding of AI-driven automation and smart manufacturing strategies.
- To develop problem-solving skills for implementing AI solutions in real-world manufacturing environments.

Syllabus:

Unit	Contents	Lecture
01.	**Introduction to Artificial Intelligence in Manufacturing:** Overview and Basics of AI- Definitions and Evolution, Industry 4.0 and Smart Manufacturing, Role of AI in Manufacturing Industries, Smart Manufacturing and Industry 4.0, Types of AI: Weak AI vs. Strong AI, Narrow AI, General AI, and Machine Learning	07 L
02.	**Machine Learning and Deep Learning for Manufacturing and its Application:** Basics and Fundamentals of Machine Learning (Supervised, Unsupervised, and Reinforcement Learning), Deep Learning and Neural Networks in Manufacturing, Applications of ML in Predictive Maintenance and Process Optimization, AI-driven Process Optimization and Quality Control, Case Studies on Machine Learning in Manufacturing and AI in Defect Detection and Demand Forecasting	07 L
03.	**AI for Predictive Maintenance and Fault Diagnosis:** Introduction to Predictive Maintenance and Condition Monitoring, AI-based Anomaly Detection Techniques, Use of IoT and Sensors for Predictive Maintenance, Case Studies on AI-enabled Fault Diagnosis.	07 L
04.	**Expert Systems and Decision Support in Manufacturing:** Introduction to Expert Systems, Knowledge Representation and Reasoning Techniques, AI-driven Decision Support Systems (DSS) in Manufacturing, Case Studies in AI for Process Planning and Scheduling.	07 L

05. Computer Vision and AI-based Quality Control: 07 L
Basics of Computer Vision and Image Processing, AI-based Inspection Systems for Defect Detection, Pattern Recognition and Object Classification, Case Studies: Vision-based Quality Control in Industries

06. Ethical Considerations, Challenges and Future Trends in AI for Manufacturing: 07 L
Ethical & Legal Aspects of AI in Manufacturing, Challenges in AI Adoption in Manufacturing, Digital Twin and AI Simulation for Manufacturing, Cybersecurity and AI-driven Risk Management, Future Trends: Generative AI, Explainable AI and Edge AI, Case Studies on Emerging AI Technologies in Manufacturing

ARTIFICIAL INTELLIGENCE IN MANUFACTURING LAB SYLLABUS:

List of Experiments: (Any seven)

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

1. Study of AI Tools for Manufacturing: AI-based software tools (Python, MATLAB, TensorFlow, OpenCV)
2. Data Acquisition and Preprocessing in AI & Manufacturing Applications
3. Machine Learning for Predictive Maintenance & Quality Control
4. AI-based Quality Inspection Using Computer Vision
5. AI-based Predictive Maintenance
6. AI in Production Planning and Scheduling
7. Deep Learning for Manufacturing Defect Detection
8. Automatic Identification and Data Capture using AI
9. AI-driven Digital Twin for Smart Manufacturing
10. AI based Fault Diagnosis and Root Cause Analysis

Course outcomes:

After successful completion of this course, students will be able to:

1. Demonstrate & Utilize proficiency in AI tools and programming for manufacturing applications.
2. Apply machine learning and deep learning models for process optimization and defect detection.
3. Develop AI-based quality inspection models using computer vision.
4. Analyze manufacturing data for predictive maintenance and fault diagnosis.
5. Implement AI-based automation and robotics for smart manufacturing processes.
6. Evaluate the impact of AI on sustainability and smart manufacturing systems.

Suggested learning resources:

Textbooks:

1. Alka Chaudhary, Intelligent Manufacturing and Industry 4.0, CRC Press
2. M. Dhivya, Artificial Intelligence (AI): Recent Trends and Applications, CRC Press
3. Rui Yang, Maiying Zhong, Machine Learning-Based Fault Diagnosis for Industrial Engineering Systems, CRC Press

Reference Book:

1. Hamid Parsaei, Manufacturing Decision Support Systems.
2. *Kamalakanta Muduli,* Intelligent Manufacturing Management Systems, Wiley.

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Course: Fundamentals Of Quantitative Techniques In Project Management

Course Code	MFG(PE)-25010	**Scheme of Evaluation**	Continuous Internal Evaluation (CIE) & ESE (End Semester Exam)	Scheme of Evaluation for Lab	CIE
Teaching Plan	3-0-2-0	**MSE+ TA**	30 + 20 Marks	CIE	100 Marks
Credits	4	**ESE**	50 Marks		

Course Objectives:

- To apply the forecasting techniques for real life applications.
- To apply network models for project analysis
- To use decision making tools for multicriteria decision making
- To develop problem-solving skills in Integer/linear /Goal programming
- To apply inventory models/ queuing models for real life applications.

Course Contents:

Unit	Contents	Lecture
01.	**Demand Forecasting:** Elements of a Good Forecast,Forecasting and the Supply Chain ,Steps in the Forecasting Process, Forecast Accuracy, Approaches to Forecasting, Qualitative Forecasts , Executive Opinions, Salesforce Opinions, Consumer Surveys, Forecasts Based on Time-Series Data, Naive Methods, Techniques for Averaging, Other Forecasting Methods, Techniques for Trend, Trend-Adjusted Exponential Smoothing, Techniques for Seasonality, Techniques for Cycles, Associative Forecasting Techniques, Simple Linear Regression, Nonlinear and Multiple Regression Analysis, Monitoring the Forecast, Choosing a Forecasting Technique,	07 L
02.	Network techniques for project management, development of project network, time estimation, determination of critical path, scheduling when resources are limit, PERT and CPM models.	07 L
03.	Multi Criteria Decision Making, Analytical Tools: Simple Additive Weighting Method (SAW), Weighted Product Method (WPM), Analytical Hierarchy Process (AHP), TOPSIS, Modified TOPSIS, Graph Theory and Matrix Approach, formulation, Applications	07 L
04.	Introduction to Integer programming, Solution of Integer programming by various methods, Goal programming and parametric programming, Linear programming models, multi goal programming, Dynamic programming models	07 L
05.	Game theory- linear programming methods to solve mixed strategy games, Various models in queuing; inventory control models,	07 L

06.	Vehicle routing problems and various mathematical models, transshipment, travelling salesman problems; Simulation modelling & analysis	07 L

Fundamentals of Quantitative Techniques in Project Management Lab:

The list of Experiments:

1. To analyse the past data and forecast the values using time series data to evaluate at least three qualitative forecasting techniques
2. To analyse averaging techniques, trend and seasonal techniques, and regression analysis, and solve typical problems. measures of forecast accuracy.
3. To analyse critical path, the sequence of activities and project's overall duration, and manage project activities effectively using CPM PERT tools
4. To analyse Case studies of scheduling and controlling project costs with crashing activities
5. To apply Simple Additive Weighting Method (SAW) method for solving MCDM case study
6. To use Weighted Product Method (WPM) for solving MCDM case study
7. To use Analytic Hierarchy Process (AHP) for solving MCDM case study
8. To use TOPSIS/Modified method for solving MCDM case study
9. To use Digraph method for solving MCDM case study
10. To solve the Goal programming/ Integer programming problem
11. To solve the inventory problem using inventory models.
12. To solve the queuing problem using Queuing Model

Course Outcomes:

At the end of course students will be able to

1. Apply forecasting techniques for real-life decision-making problems.
2. Analyze various network models in real life case studies
3. Apply multi criteria decision making in real life case studies
4. Solve Integer Programming, Linear Programming, Goal Programming models
5. Apply inventory models/ queuing models for real life applications

References:

1. Sharma J.K. : Operations Research Theory & Applications, Macmillan India Ltd.
2. Hamdy A. Taha : Operations Research, An Introduction, PHI Learning Pvt. Ltd., New Delhi.
3. Wagner Harvey M. : Principles of Operations Research with Applications to Managerial Decisions, Prentice Hall of India Pvt. Ltd., New Delhi.
4. Shenoy G.V. : Linear Programming Methods and Applications, New Age International, 2007
5. Prasanna Chandra, Project Planning: Analysis, Selection, Implementation and Review, Tata McGraw Hill. 7th Edition, 2009
6. Narendra Singh, Project Management and Control, HPH, 2003

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Wellesley Road, Chhatrapati Shivajinagar, Pune - 411005
Course: MDM: PRODUCTION PLANNING

Course Code	**PCC**	**Scheme of Evaluation**	MSE,TA & ESE
Teaching Plan	3-1-0-1	MSE & TA	30+20
Credits	4	ESE	50

Course Objectives:

The objectives of this course are to enable students to:

1. Develop a comprehensive understanding of Enterprise Resource Planning (ERP) systems, with emphasis on the role of Production Planning (PP) as the core driver of manufacturing operations.
2. Explain the relationship between enterprise-level organizational structures (Client and Company Code) and plant-level manufacturing entities such as plants and storage locations.
3. Illustrate the significance of production master data, including Bills of Materials (BOMs), routings, and work centres, in enabling integrated and automated manufacturing processes.
4. Compare and evaluate different manufacturing environments such as Discrete, Repetitive, and Process manufacturing, and identify their applicability within ERP systems.
5. Understand and explain the principles of Material Requirements Planning (MRP), including demand management, capacity considerations, and lead-time planning.
6. Examine and simulate the complete "Plant-to-Produce" business process, covering demand forecasting, production execution, and financial settlement within an integrated ERP environment.

Syllabus:

Unit	Contents	Hrs
01	Introduction to Production Planning (PP): Introduction to Production Planning: An overview – Introduction – Scope, Aim of Production Planning, Objective, Importance of Integrated approach to Production Planning	6L
02	PP Organizational Structures: Enterprise structure overview, Work Centers, Production Planning relevant organizational elements, Production Scheduling Profile	6L
03	Master Data: Basic Features of PP module in ERP systems: Terms used in PP module, Material master data, BOM, Routing	7L
04	Plan to Produce Business Processes: Overview of end-to-end Plan-to-Produce process, Demand management and requirement planning, Production planning strategies (Make-to-Stock, Make-to-Order)	7L
05	Material Planning & Scheduling: Material Requirements Planning (MRP) concepts and objectives, Lead time scheduling and backward/forward scheduling, Capacity planning and scheduling	7L
06	Production Order Management: Overview of production order lifecycle, Order release and material availability check, Order scheduling and capacity requirements, Production order reporting and monitoring	9L
	Total	42L

Course outcomes:

Student will show their ability at a professional level to:

1. *Explain* the organizational structures in a manufacturing environment, including plants, storage locations, and work centres, and their roles in production planning and execution.
2. *Create and maintain* complex production master data such as material masters, multi-level bills of materials (BOMs), and routings to ensure accurate and consistent production data flow.
3. *Apply* appropriate demand planning and production planning strategies (Make-to-Stock and Make-to-Order) to generate effective production and procurement proposals.
4. *Execute and analyze* Material Requirements Planning (MRP) runs and *interpret* exception messages to address rescheduling issues and material shortages.
5. *Manage* the complete production order lifecycle, including order creation, material availability checks, goods movements, and production confirmations.
6. *Integrate and coordinate* Production Planning (PP) processes with Materials Management (MM), Sales and Distribution (SD), and Finance/Controlling (FI-CO) modules to support seamless end-to-end business operations.

Suggested learning resources:
Textbooks:

1. Manufacturing Planning and Control for Supply Chain Management by F. Robert Jacobs, William Lee Berry, and Thomas E. Vollmann.
2. Production Planning and Control: Text and Cases by S.K. Mukhopadhyay.
3. Integrated Business Processes with ERP Systems" by Simha R. Magal and Jeffrey Word

Reference Books:

1. Production, Planning and Control & Industrial Management" by K.C. Jain and L.N. Agarwal.
2. Material Requirements Planning with SAP S/4HANA" by Caetano Almeida (SAP PRESS**)** W.L., Whybark, D.C., Jacobs, F.R. *Manufacturing Planning and Control for Supply Chain Management* McGraw-Hill.
3. Modern Production and Operations Management" by Elwood S. Buffa and Rakesh K. Sarin.

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Course: SMART MANUFACTURING & SIMULATION LABORATORY (SMSL)

Course Code	MFG-25010	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-1 = 2	CIE	100
Credits	1		

Course Objectives:

- Understand fundamental concepts and principles underlying smart manufacturing systems
- Apply Simulation Software effectively to model, simulate, and analyze complex manufacturing and logistics processes
- Analyze simulation data to identify bottlenecks, resource utilization, throughput, and system performance characteristics for effective decision-making
- Design and implement IoT-based experiment for real-time data acquisition, remote monitoring, and automated control in manufacturing environments
- Evaluate alternative smart manufacturing scenarios and logistical strategies using simulation models and IoT experiments
- Demonstrate teamwork, effective communication, and technical documentation skills through collaborative lab experiments, simulation projects

Syllabus:

Lab	List of Lab Experiments	Hrs.
01	Basic elements of simulation model building using simulation software	2 hrs.
02	Building and simulation of a multi-stage simulation models in software	4 hrs.
03	Simulation of Manufacturing/Warehouse/Logistics models	2 hrs.
04	Simulation of Chemical Manufacturing Plants (continuous production)	2 hrs.
05	Simulate and control a conveyor belt system	2 hrs.
06	Case Study 1: Industrial application-based simulation model development	2 hrs.
07	Case Study 2: Industrial application-based simulation model development	2 hrs.
08	Real-time Monitoring and Control of a Manufacturing Process using IoT Sensor data collection and communication over the network using ESP-32/Arduino	4 hrs.
09	Simulation of machine tool design from an ergonomics perspective using ErgoMaster	4 hrs.
	Total	**24 hrs.**

Course outcomes:

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

1. Develop simulation models for various manufacturing and logistics scenarios using a simulation software package
2. Analyze simulation data from various manufacturing and logistics scenarios
3. Design IoT systems with networked sensors and actuators
4. Develop basic C++ code used for Arduino and ESP-32 based microcontrollers used in IoT.

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PROJECT STAGE-II (Semester-VI)

Course Code	MFG-25011	**Scheme of Evaluation**	CIE
Teaching Plan	0-0-2-1	**CIE**	100
Credits	2		

Sr No	Items	Description of activity
1	**Scope (TRL-3)**	Continuation of Project-I, Planning, fabrication and development of hardware / software and execution; relevant standards.
2	**Self-Study material for the student**	The department shall recommend relevant online / offline self-study materials on Incubation, Innovation (online / offline)
3	**End Semester Evaluation process**	The end semester evaluation shall be based on project work in power point presentation and a project report. The evaluation shall be done by the panel of faculty members, at least three members including one of them is project guide.

Evaluation sheet for Project -II

MIS No	Name of student	Planning	Development of hardware / software	Experimentation	Project Report	Viva Voce and presentation skill	Out of 50 marks
		10 M	10M	10M	10M	10M	

INTERNSHIP-III,
(After semester VI, Summer Internship)

Sr No	Items	Type of Internship to be undertaken
1	**Nature of Internship**	Industry / R&D labs / Education institutes (HEI less than 100 NIRF rank) This should be decided by the nature of Project-I selected by the group of students in the 5th semester. A project guide should assist in grooming the student group in relevant areas to enhance their knowledge and skills.
2	**End Semester Evaluation process**	Individual student / Group of students shall submit a report followed by viva voce by the department level faculty members on the project report prepared by them. A template for report writing and evaluation format will be provided by the Nodal Officer, COEP Tech.

Exit Course options for B.Voc in Manufacturing Sciences

Two (02) Skill based Courses of 8 credits

Sr. No.	Course Type	Course Name	Teaching Scheme					Credits
			L	T	P	S	Hrs	
1	SEC	Computer Aided Inspection	0	0	8	1	5	4
2	SEC	Casting & Welding Technology	0	0	8	1	5	4

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Course: COMPUTER AIDED INSPECTION (CAI)

Course Code		**Scheme of Evaluation**	CIE
Teaching Plan	0-0-8-1	**CIE**	100 Marks
Credits	4		

Course Objectives:
At the end of this course, students will be able to …

- Understand the basic elements of computer aided inspection (CAI)
- Understand the in-process measurement using gauge system
- Measure geometric and dimensional tolerances
- Examine alignment of the Machine tool

List of experiments:

1. Study and demonstration of Coordinate Measuring Machine (CMM)
2. Measurement of dimensional and Geometric Tolerance of the part using CMM
3. Study and demonstration of interferometer
4. Measurement of gear tooth profile using profile projector
5. Study and demonstration of Vision Measurement System
6. Machine Tool Alignment testing for CNC Lathe (Minimum 3 test)
7. Machine Tool Alignment testing for VMC (Minimum 3 test)
8. Study and demonstration of Automatic Force Microscope
9. In process Pneumatic Gauging
10. Assignment on various integrated software packages application for Computer Aided Inspection

Course Outcomes:
At the end of this course, students will be able to

1. Understand the computer aided inspection (CAI)
2. Measure Analyze the gear tooth profile terminology
3. Ensure the quality of the product by inprocess gauging
4. Inspecting the alignment of CNC & VMC

Suggested learning resources:

Textbooks:

1. Computer-Aided Inspection Planning: Theory and Practice *Abdulrahman Al-Ahmari, Emad Abouel Nasr, Osama Abdulhameed* — 1st Edition Routledge
2. Automated Inspection and Quality Assurance *Stanley L. Robinson, Richard Kendall Miller* — 1st Edition Routledge
3. Machine Vision: Automated Visual Inspection — Theory, Practice and Applications *Jürgen Beyerer, Fernando Puente León, Christian Frese* — 1st Edition

Reference books:

1. Integrated Imaging and Vision Techniques for Industrial Inspection: Advances and Applications *Zheng Liu, Hiroyuki Ukida, Pradeep Ramuhalli, Kurt Niel (Editors)* **—** 1st Edition Springer
2. Machine Vision Handbook *Bruce G. Batchelor (Editor)* **—** 1st Edition Springer
3. Smart Inspection Systems: Techniques and Applications of Intelligent Vision *Duc T. Pham, R. J. Alcock* **—** 1st Edition

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Course: CASTING & WELDING TECHNOLOGY (BVOC)

Course Code		**Scheme of Evaluation**	CIE
Teaching Plan	0-0-8-1	CIE	100
Credits	04		

Course Objectives:

1. Learn practical overview of various welding process and learn various welding standards
2. Gain an insight of sand preparation and foundry equipment
3. Enhance the practical skills in welding and casting technology
4. Analyze various advanced welding processes.

List of Experiments :

Welding :

1) Perform welding of Mild steel Plates by Gas Metal Arc Welding process. (GMAW)
2) Perform welding on of Mild steel/Stainless steel /Aluminium sheets by
    a. Gas Tungsten Arc Welding (GTAW).
3) Perform welding on Mild steel/Stainless steel sheets using Resistance Spot Welding for overlapping sheets.
4) Perform welding on Aluminum sheets using Friction Stir welding and Friction Stir Spot welding.
5) Perform welding using Mild steel/Stainless steel Laser Beam Welding (LBW).

Casting:

1. Understand design consideration of gating, riser and estimating cooling time for casting
2. Sand preparation and Testing (Determination of moisture content, Determination of Permeability)
3. Demonstration of production of a part of Cast iron using Pit Furnace/Induction Furnace
4. Inspection of Cast component (visual) and preparing report. The report includes causes of various defects.
5. Demonstration of Plastic moulding/Injection Moulding.

Course outcomes:

1. Learn the fundamentals and working of various conventional and advanced welding processes
2. Understand practical aspects involved in various welding process
3. Prepare and select the process parameters for various welding process
4. Understand the moulding sand preparation and various aspects involved into it.
5. Apply the design consideration of gating, riser and estimating cooling time for casting

Suggested learning resources:

Textbooks:

- Little R.L., "Welding and Welding Technology", Tata McGraw Hill Publishing Co., Ltd., New Delhi, 34th reprint, 2008.
- Christopher Davis. "Laser Welding- Practical Guide". Jaico Publishing House, 1994.
- Mishra. R.S and Mahoney. M.W, "Friction Stir Welding and Processing", ASM,2007.
- Heine, R. W. Loper, C.R. and Rosenthal, P.C. "Principles of Metal Casting"
- Ghosh A. and Malik, A.K. "Manufacturing Science ", Affiliated East-West Press Pvt. Ltd.
- Jain P.L "Principles of Focundry Techonology, McGraw Hill Books

Reference books:

- John Campbell, "Complete Casting Handbook,Metal Casting Processes, Metallurgy, Techniques and Design", 2nd Edition 2015, Springer.
- K.G. Swift and J.D. Booker, "Manufacturing Process Selection Handbook," 2013 Elsevier
- Davis A.C., "The Science and Practice of Welding", Cambridge University Press, Cambridge, 1993.
- HA. Davidson,"Handbook of Precision Engineering:Joining Techniques" 1973Red Globe Press London
- A. F. Manz, "The Welding Power Handbook: A Basic Manual on Theory and Use of Arc Welding Power Supplies"1973,Amer Welding Society

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- https://nptel.ac.in/courses/112103305
    - https://onlinecourses.nptel.ac.in/noc21_me82/preview