VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

- To establish a world class academy for Manufacturing and Industrial Engineering

MISSION OF THE DEPARTMENT

- Curriculum development with state-of-the-art technologies
- Pursue research interests of Manufacturing and Industrial engineering
- Consultancy in design, Manufacturing and industrial engineering
- Industry-Institute interaction
- Equipping Laboratories with state-of-the-art equipment

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	Graduates of the programme will be capable of integrating Engineering fundamentals and advanced Manufacturing Engineering concepts.
PEO2	Graduates of the programme will be professionally competent for gainful employment in Manufacturing functions and sustain future challenges.

PROGRAMME OUTCOMES (POs)

PO1	An ability to independently carry out research /investigation and development work to solve practical problems pertaining to manufacturing domain.
PO2	An ability to write and present a substantial technical report/document
PO3	Students should be able to demonstrate a degree of mastery over the manufacturing technology domain. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

CURRICULUM

SEMESTER I

Code	Course of Study	Credit
PR601	Machining Science and Technology	4
PR603	Advanced Forming Technology	4
PR605	Manufacturing Management	4
	Programme Elective I	3
	Programme Elective II	3
	Programme Elective III / Online (NPTEL)	3
PR607	Advanced Material Processing Lab.	2
		23

SEMESTER II

Code	Course of Study	Credit
PR602	Welding and Additive Manufacturing	4
PR604	Advanced Tooling and Automated Inspection	4
PR606	Production Automation and CNC Technology	4
	Programme Elective IV	3
	Programme Elective V	3
	Programme Elective VI / Online (NPTEL)	3
PR608	Automation & CIM Lab	2
PR610	Process Modelling and Additive Manufacturing Lab	2
		25

SUMMER TERM (evaluation in the III semester)

Code	Course of Study	Credit
PR644	Internship / Industrial Training / Academic Attachment (I/A) (6 weeks to 8 weeks)	2

SEMESTER III

Code	Course of Study	Credit
PR645	Project Work (Phase I)	12

SEMESTER IV

Code	Course of Study	Credit
PR646	Project Work (Phase II)	12

OPEN ELECTIVES (OE) / ONLINE COURSE (OC) (To be completed between I to IV semester)

Sl. No.	Code	Course of Study	Credit
1.		Online courses shall be dynamically updated based on student request and due approval through circulation.	3

PROGRAMME ELECTIVES (PE)

Sl. No.	Code	Course of Study	Credit
1.	PR611	Modeling of Manufacturing Processes	3
2.	PR612	Advances in Polymer matrix Composites	3
3.	PR613	Heat Treatment Processes	3
4.	PR614	Industrial Welding Applications	3
5.	PR615	Laser Material Processing	3
6.	PR616	Machine Tool Technology	3
7.	PR617	Manufacturing of Non-metallic Products	3
8.	PR618	Mechanical Behaviour of Materials	3
9.	PR619	Mechanics of Composite Materials	3
10.	PR620	Non-Destructive Testing	3
11.	PR621	Smart Materials and MEMS	3
12.	PR622	Surface Engineering	3
13.	PR623	Tribology	3
14.	PR624	Friction Materials	3
15.	PR625	Advanced Casting Processes	3
16.	PR626	Computational methods in Manufacturing	3
17.	PR627	Additive Manufacturing	3
18.	PR628	Micro/Nano Manufacturing	3
19.	PR629	Design for Additive Manufacturing	3
20.	PR630	Computer Aided Design and Manufacturing	3
21.	PR631	Control of Manufacturing Processes	3
22.	PR632	Design for Manufacture	3
23.	PR633	Manufacturing Automation and Mechatronics	3
24.	PR634	Product Design and Development	3
25.	PR635	Robotics	3
26.	PR636	Terotechnology	3
27.	PR637	Tolerance Technology	3
28.	PR638	Modeling, Simulation and Analysis	3
29.	PR639	Supply Chain Management	3

30.	PR640	Automation and control	3
31.	PR641	Data Science for Manufacturing	3
32.	PR642	Condition Monitoring of Machine	3
33.	PR643	Human Machine Interaction for Manufacturing	3

OPEN ELECTIVES (OE) (List some courses from Programme Electives, that will be Open Electives for other Specialization, if it is offered as Programme Elective for the respective specialization)

Sl. No.	Code	Course of Study	Credit
1.	PR628	Micro/Nano Manufacturing	3
2.	PR634	Product Design and Development	3
3.	PR635	Robotics	3
4.	PR641	Data Science for Manufacturing	3
5.	PR642	Condition Monitoring of Machine	3
6.	PR643	Human Machine Interaction for Manufacturing	3

MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Sl. No.	Code	Course of Study	Credit
1.		Microcredit courses shall be dynamically updated based on student request and due approval through circulation	

M. Tech. (Manufacturing Technology) Total minimum credits required: 80

CODE	Semester 1	L	T	P	C	CODE	Semester 2	L	T	P	C
PR601	Machining Science and Technology	4	0	0	4	PR602	Welding and Additive Manufacturing	4	0	0	4
PR603	Advanced Forming Technology	3	1	0	4	PR604	Advanced Tooling and Automated Inspection	2	1	2	4
PR605	Manufacturing Management	3	1	0	4	PR606	Production Automation and CNC Technology	4	0	0	4
-----	Elective I	3	0	0	3	-----	Elective IV	3	0	0	3
-----	Elective II	3	0	0	3	-----	Elective V	3	0	0	3
-----	Elective III	3	0	0	3	-----	Elective VI	3	0	0	3
-----	Elective VII (OE/OC)	3	0	0	3	-----	Elective VIII (OE/OC)	3	0	0	3
PR607	Advanced Material Processing Lab.	0	0	4	2	PR608	Automation & CIM Lab.	0	0	4	2
Total		**22**	**2**	**4**	**26**	PR610	Process Modelling and Additive Manufacturing Lab.	0	0	4	2
CODE	**Semester 3**	**L**	**T**	**P**	**C**	**Total**		**22**	**1**	**10**	**28**
PR644	Summer Term: Internship/Industrial Training/Academic Attachment (I/A)	6 to 8 weeks			**2**	**CODE**	**Semester 4**	**L**	**T**	**P**	**C**
PR645	Project Work – Phase I	**0**	**0**	**24**	**12**	PR646	Project Work – Phase II	**0**	**0**	**24**	**12**

LIST OF ELECTIVES

CODE	Materials & Process Stream	L	T	P	C	CODE	Product & System Stream	L	T	P	C
PR611	Modeling of Manufacturing Processes	3	0	0	3	PR630	Computer Aided Design and Manufacturing	3	0	0	3
PR612	Advances in Polymer matrix Composites	3	0	0	3	PR631	Control of Manufacturing Processes	3	0	0	3
PR613	Heat Treatment Processes	3	0	0	3	PR632	Design for Manufacture	3	0	0	3
PR614	Industrial Welding Applications	3	0	0	3	PR633	Manufacturing Automation and Mechatronics	3	0	0	3
PR615	Laser Material Processing	3	0	0	3	PR634	Product Design and Development	3	0	0	3
PR616	Machine Tool Technology	3	0	0	3	PR635	Robotics	3	0	0	3
PR617	Manufacturing of Non- metallic Products	3	0	0	3	PR636	Terotechnology	3	0	0	3

PR618	Mechanical Behaviour of Materials	3	0	0	3	PR637	Tolerance Technology	3	0	0	3
PR619	Mechanics of Composite Materials	3	0	0	3	PR638	Modeling, Simulation and Analysis	3	0	0	3
PR620	Non-Destructive Testing	3	0	0	3	PR639	Supply Chain Management	3	0	0	3
PR621	Smart Materials and MEMS	3	0	0	3	PR640	Automation and control	3	0	0	3
PR622	Surface Engineering	3	0	0	3	PR641	Data Science for Manufacturing	3	0	0	3
PR623	Tribology	3	0	0	3	PR642	Condition Monitoring of Machine	3	0	0	3
PR624	Friction Materials	3	0	0	3	PR643	Human Machine Interaction for Manufacturing	3	0	0	3
PR625	Advanced Casting Processes	3	0	0	3						
PR626	Computational methods in Manufacturing	3	0	0	3						
PR627	Additive Manufacturing	3	0	0	3						
PR628	Micro/Nano Manufacturing	3	0	0	3						
PR629	Design for Additive Manufacturing	3	0	0	3						

COURSE OUTCOME AND PROGRAMME OUTCOME MAPPING

PROGRAMME CORE (PC)

Course Outcomes: On successful completion of the course, students will be able to:

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able to	PO1	PO2	PO3
PR601	Machining Science and Technology	CO1	Describe the working principle of advanced machining processes	3	2	3
		CO2	Explain the effect of various process parameters on the performance of advanced machining processes	3	2	3
		CO3	Summarise the merits, demerits and applications of advanced machining processes	3	2	3
		CO4	Identify the suitable advanced machining processes based on the applications	3	2	3
PR603	Advanced Forming Technology	CO1	Understand the basic concepts plastic deformation	3	2	3
		CO2	Analyze plastic deformation processes	3	2	3
		CO3	Identify and analyze the requirement of different high velocity forming processes, micro- forming processes and severe plastic deformation processes	3	2	3
		CO4	Interpret and evaluate crystallographic texture development by deformation processes	3	2	3
PR605	Manufacturing Management	CO1	Understand the role of manufacturing management in organizational decision making	3	2	3
		CO2	Build and analyze	3	2	3

			quantitative models for organizational decision making			
		CO3	Select appropriate tools for decision making and apply tools for modelling of complex systems	3	2	3
		CO4	Analyze the outcome and offer suggestions for improvement	3	2	3
PR602	Welding and Additive Manufacturing	CO1	Understand fundamental principle of different process in welding and various additive manufacturing processes	3	2	3
		CO2	Design and characterize the process parameters for welding and additive manufacturing processes	3	2	3
		CO3	Inspect the quality of welded and additive manufactured products	3	2	3
PR604	Advanced Tooling and Automated Inspection	CO1	State of Art in Tooling in Manufacturing and Inspection	3	2	3
		CO2	Design and Develop tooling for modern manufacturing	3	2	3
		CO3	Design and Develop Automated Inspection Systems	3	2	3
PR606	Production Automation and CNC Technology	CO1	Develop advanced machine language for operating machine tools	3	2	3
		CO2	Apply computer numerical control techniques for making macro and micro products	3	2	3
		CO3	Understand cellular manufacturing techniques	3	2	3

LABORATORY

Course Code	Course Title	CO	Course Outcomes At the end of the course student will be able to	PO1	PO2	PO3
PR607	Advanced Material Processing Lab.	CO1	Describe the influence of parameters on various machining processes	3	3	3
		CO2	Recognize the various metal joining techniques	3	3	3
		CO3	Analyze the behavior of metals during deformation	3	3	3
		CO4	Illustrate contemporary manufacturing techniques	2	3	3
PR608	Automation & CIM Lab.	CO1	Apply fluid power control system for industrial automation	3	3	3
		CO2	Generate G-codes/M-Codes for the given part drawing using CAD software by simulating manufacturing process	3	3	3
		CO3	Understand and write CNC Programme: G-codes/M-Codes for the given part drawing	3	3	3
		CO4	Write the Robot programming and understand function of ASRS	3	3	3
PR610	Process Modelling and Additive Manufacturing Lab.	CO1	To model and simulate of metalworking processes	3	2	2
		CO2	Expertise in performing simulation of metal-based AM processes	3	2	3
		CO3	Execute product development phases	3	2	3
		CO4	Develop environmentally friendlier products	3		3

PROGRAMME ELECTIVES (PE)

Course Code	Course Title	CO	Course outcomes At the end of the course student will be able to	PO1	PO2	PO3
PR611	Modeling of Manufacturing Processes	CO1	Apply and solve non-linear problems in numerical methods	3	2	
		CO2	Develop numerical methods for solving	3	2	3

			metal working problems			
		CO3	Perform mathematical and numerical models for AM Processes	3	2	3
PR612	Advances in Polymer matrix Composites	CO1	Acquire the knowledge of the polymers matrix and reinforcement materials used in polymer matrix composites	3	2	3
		CO2	Describe manufacturing methods and characterization of polymer matrix composites	3	2	3
		CO3	Perform Forming, Joining & machining operation to make product from the polymer matrix composites	3	2	3
		CO4	Select and Apply the appropriate polymer matrix composites material for recent industrial applications & confront environmental issues	3	2	3
PR613	Heat Treatment Processes	CO1	Identify the effect of heat treatment in alloying elements	3	2	3
		CO2	Apply surface modification techniques	3	2	3
		CO3	Find the defects occurring in heat treated parts	3	2	3
PR614	Industrial Welding Applications	CO1	Apply the knowledge of welding in Heavy Engineering	3	2	3
		CO2	Apply the knowledge of welding in Automotive Industries	3	2	3
		CO3	Apply the knowledge of welding in Nuclear Power	3	2	3
PR615	Laser Material Processing	CO1	Compare the types of lasers and its applications	3	2	3
		CO2	Employ laser for surface engineering, welding, cutting and drilling	3	2	3
		CO3	Analyse the micro	3	2	3

			machining processes by Laser			
PR616	Machine Tool Technology	CO1	Identify various parts of machine tools	3	2	3
		CO2	Apply various design aspects of spindles and bearings	3	2	3
		CO3	Reduce vibration and chatter developing on machine tools	3	2	3
PR617	Manufacturing of Non- metallic Products	CO4	Describe the types of polymers, rubbers and its manufacturing techniques	3	2	3
		CO2	Describe the application, types of glass and ceramics and their manufacturing methods	3	2	3
		CO3	Knowledge in types of composites and their manufacturing techniques	3	2	3
PR618	Mechanical Behaviour of Materials	CO1	Understand structure and deformation mechanics of materials	3	2	3
		CO2	Understand strengthening mechanisms	3	2	3
		CO3	Identify different modes of failure of materials	3	2	3
		CO4	Evaluate mechanical properties of different materials	3	2	3
PR619	Mechanics of Composite Materials	CO1	Classify the composite materials	3	2	3
		CO2	Categorize the properties of composite materials	3	2	3
		CO3	Apply the knowledge of matrix in composite materials	3	2	3
PR620	Non-Destructive Testing	CO1	Select appropriate non-destructive techniques	3	2	3
		CO2	Apply surface modification techniques	3	2	3
		CO3	Compare the merits of various non-destructive techniques	3	2	3
PR621	Smart Materials and MEMS	CO1	Describe the overview of different kinds of smart	3	2	3

			materials and their applications			
		CO2	Describe the various fabrication processes of smart materials and MEMS	3	2	3
		CO3	Deliberate the fundamentals of mechanics for design of smart materials	3	2	3
PR622	Surface Engineering	CO1	Compare the use of different surface engineering techniques	3	2	3
		CO2	Select appropriate thermal process to alter the material surface	3	2	3
		CO3	Apply laser for surface modification	3	2	3
PR623	Tribology	CO1	Apply the knowledge of tribology in industries	3	2	3
		CO2	Identify the friction and its effect	3	2	3
		CO3	Analyse wear of different forms	3	2	3
PR624	Friction Materials	CO1	Provide a comprehensive idea regarding the friction materials and its performance	3	2	3
		CO2	Explore various ingredients and fabricate different types of friction composites	3	2	3
		CO3	Demonstrate knowledge of various industrial standards for testing the friction composites	3	2	3
		CO4	Identify the difference between OE and after-market friction materials	3	2	3
PR625	Advanced Casting Processes	CO1	Design of appropriate casting system to make components in industry	3	2	3
		CO2	Identify and select suitable casting process to make components in industry	3	2	3
PR626	Computational methods in Manufacturing	CO1	Apply the numerical concepts and techniques for manufacturing	3	2	3

			engineering problems			
		CO2	Understand and apply the statistical techniques in manufacturing processes	3	2	3
		CO3	Apply optimization tools for manufacturing problems	3	2	3
PR627	Additive Manufacturing	CO1	Understand the importance of time compression technologies	3	2	3
		CO2	Selection of appropriate technology for the application	3	2	3
		CO3	Exposure to RP software packages	3	2	3
PR628	Micro/Nano Manufacturing	CO1	Principles of various micro and nano manufacturing processes	3	2	3
		CO2	Various machine tools and techniques	3	2	3
		CO3	Recent developments in micro and nano manufacturing	3	2	3
		CO4	Various measuring techniques used for micro/nano components	3	2	3
PR629	Design for Additive Manufacturing	CO1	Understand DfAM concepts	3		3
		CO2	Expertise in DfAM methods/tools	3	2	3
		CO3	Competence to apply DfAM methods to industrial products	3	2	3
PR630	Computer Aided Design and Manufacturing	CO1	Define the principles of optimum design	3	2	3
		CO2	Apply surface modelling techniques	3	2	3
		CO3	Analyze production systems at operation level	3	2	3
PR631	Control of Manufacturing Processes	CO1	Apply and interfere the application of statistical methods in manufacturing processes	3	2	3
		CO2	Identify the causes of process variation through statistical process control	3	2	3

		CO3	Apply the experimental design concepts in manufacturing process for problem solving	3	2	3
PR632	Design for Manufacture	CO1	Apply various design rules in manufacturing processes	3	2	3
		CO2	Evaluate the process by design guidelines for optimum design	3	2	3
		CO3	Analyze design alternatives in the manufacture of components	3	2	3
PR633	Manufacturing Automation and Mechatronics	CO1	Identify the various types of control valves	3	2	3
		CO2	Apply PLCs in circuits	3	2	3
		CO3	Select appropriate hydraulic and pneumatic circuits	3	2	3
PR634	Product Design and Development	CO1	Understand the challenges and advancements of product development process	3	2	3
		CO2	Execute various phases of product development	3	2	3
		CO3	Develop environmentally friendly products/processes	3	2	3
PR635	Robotics	CO1	Identify the components of a robot	3	2	3
		CO2	Program robots for different applications	3	2	3
		CO3	Introduce robots in various in various manufacturing techniques	3	2	3
PR636	Terotechnology	CO1	Increase the reliability of a system	3	2	3
		CO2	Conduct reliability analysis	3	2	3
		CO3	Identify appropriate models for reliability measurement	3	2	3
PR637	Tolerance Technology	CO1	Identify the general dimensioning techniques	3	2	3
		CO2	Apply the principles of tolerance in Manufacturing	3	2	3

		CO3	Calculate the optimum material requirement	3	2	3
		CO4	Identify the suitable geometrical tolerancing methods related to components function, manufacturing and inspection	3	2	3
PR638	Modeling, Simulation and Analysis	CO1	Develop manufacturing models of discrete event systems	3	2	3
		CO2	A generation of uncertainty using random numbers and random variates	3	2	3
		CO3	Perform input, output analysis: Verification and validation of models and optimization	3	2	3
PR639	Supply Chain Management	CO1	Explain the major building blocks, major functions, major business processes, performance metrics, and major decisions in supply chain networks	3	2	3
		CO2	Summarize the foundation for design and analysis of supply chains and synthesize advanced and specialized concepts, principles and models for operational and strategic improvement	3	2	3
		CO3	Analytically examine the supply chain of organizations and measure performance improvement	3	2	3
PR640	Automation and control	CO1	Describe the open-loop and closed-loop control system used in practice	3	2	3
		CO2	Compare the performance of different control systems by using both the time response and the frequency response method	3	2	3
		CO3	Develop practical skills in	3	2	3

			designing, simulating, and implementing control systems using modern software tools			
PR641	Data Science for Manufacturing	CO1	Demonstrate the relevance and application of data science in solving manufacturing engineering problems.	1	2	3
		CO2	Develop proficiency in Python and statistical methods, enabling the students to analyze and interpret data in the context of manufacturing.	2	2	3
		CO3	Apply machine learning algorithms to real-world manufacturing processes, optimizing efficiency and improving quality through data-driven decision-making.	3	2	3
PR642	Condition Monitoring of Machine	CO1	Understand the condition-based monitoring used in industries	3	2	3
		CO2	Apply condition monitoring techniques.	3	2	3
		CO3	Analyze the signals in time and frequency domains.	3	2	3
		CO4	Diagnose the faults in machines.	3	2	3
PR643	Human Machine Interaction for Manufacturing	CO1	Analyze and apply cognitive psychology principles and ergonomic design principles to enhance human-machine interactions and improve system usability in manufacturing settings.	2	2	2
		CO2	Evaluate and implement usability testing methods, including statistical hypothesis testing, to assess and refine interfaces and systems to solve manufacturing challenges.	2	2	3
		CO3	Comprehend the	2	2	2

			effectiveness of Augmented Reality (AR), Virtual Reality (VR), and haptics technologies in enhancing manufacturing processes			

3 - High; 2 - Medium; 1 - Low

First Semester:
Programme Core (PC):

Course Code	:	PR601
Course Title	:	**Machining Science and Technology**
Type of Course	:	PC
Prerequisites	:	
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart the knowledge of working principle of advanced machining processes
CLO2	To teach the influence of parameters on the performance of advanced machining processes
CLO3	To educate the merits, demerits and applications of advanced machining processes
CLO4	To edify the applications of advanced machining processes

Course Content

Metal Cutting Technology: Introduction to metal cutting - tool nomenclature and cutting forces - thermal aspects of machining - tool materials - tool life and tool wear - traditional and nontraditional machining.

Mechanical Processes: Ultrasonic Machining - Water Jet Machining - Abrasive Jet Machining - Abrasive Water Jet Machining - Ice Jet Machining - Magnetic Abrasive Finishing – working principle, merits, demerits and applications.

Chemical and Electrochemical Processes: Chemical Milling - Photochemical Milling - Electropolishing - Electrochemical Machining - Electrochemical Drilling - Shaped Tube Electrolytic Machining – working principle, merits, demerits and applications.

Thermal Processes: Electric Discharge Machining - Laser Beam Machining - Electron Beam Machining - Plasma Beam Machining - Ion Beam Machining – working principle, merits, demerits and applications.

Hybrid Processes: Electrochemical Grinding, Honing, Superfinishing and Buffing - Ultrasonic Assisted ECM - Electroerosion Dissolution Machining - Abrasive Electrodischarge Machining - EDM with Ultrasonic Assistance - Laser Assisted Machining– working principle, merits, demerits and applications. Role of machining in metal additive manufacturing

References

1.	Bhattacharya "Metal Cutting Theory and Practice", New Central Book Agency (p) Ltd., Calcutta1984
2.	Boothroy. D. G. and Knight. W.A "Fundamentals of Machining and Machine

	tools", 3rd Edition, Taylor & Francis, New York, 2006
3.	Hassan Abdel – Gawad El-Hofy "Advanced Machining Processes", McGraw, New York, 2005
4.	Metals Handbook. Vol. 16, Machining. Materials Park; OH: ASM International, 1995
5.	Kalpakjian, S “Manufacturing Processes for Engineering Materials”, India: Pearson Education, 2009
6.	Brown, J “Advanced Machining Technology Handbook”, New York: McGraw-Hill, 1998
7.	McGeough, J “Advanced Methods of Machining”, London. New York: Chapman and Hall, London, 1988
8.	Rumyantsev, E and Davydov, A “Electrochemical Machining of Metals”, Moscow:Mir Publishers, 1989
9.	Xichun Luo and Yi Qin “Hybrid Machining: Theory, Methods, and Case Studies”, Academic press, 2018

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the working principle of advanced machining processes
CO2	Explain the effect of various process parameters on the performance of advanced machining processes
CO3	Summarise the merits, demerits and applications of advanced machining processes
CO4	Identify the suitable advanced machining processes based on the applications

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR603
Course Title	:	**Advanced Forming Technology**
Type of Course	:	PC
Prerequisites	:	
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand basics of plastic deformation
CLO2	To be able to make mathematical analysis of plastic deformation processes
CLO3	To understand different high velocity forming processes, micro-forming process and severe plastic deformation processes
CLO4	To acquire knowledge on texture development by different plastic deformation processes

Course Content

Basics of plastic deformation: Mohr's circle, plastic stress-strain relationship Levy-Von Mises equations and Prantl-Reuses equations, plastic work, Plastic instability, Isotropic and anisotropic yield criteria, Yield Locus, Work hardening. Effect of strain rate and temperature, Formability.

Methods of load calculation including slab method, slip line field theory, FEM, upper and lower bound methods. Analysis of processes like open-die forging, wire and tube drawing, extrusion, flat rolling, Sheet metal forming.

High velocity forming methods, superplastic forming, hydroforming, isothermal forging. Incremental forming, fine blanking.

Micro-forming: Scaling laws, Size Effects in Micro-forming, Micro-forming techniques: micro-bending, micro-deep drawing, micro-rolling, micro-extrusion.

Severe plastic deformation by Equal Channel Angular Processing, High pressure torsion, Multi-directional Forging, Accumulative roll bonding, Cryo-rolling. Crystallographic texture, representation and measurement of texture, texture development by different plastic deformation process.

References

1.	Hosford W.F and Caddell, R.M, Metal Forming Mechanics and Metallurgy, Cambridge University Press, 2007
2.	Dieter, G.E., Mechanical Metallurgy, McGraw Hill, 2001
3.	Juneja B.L., Fundamentals of Metal Forming processes, New Age International (P) Ltd., 2013
4.	Belzalel Avitzur, Metal Forming- Processes and Analysis, Tata McGraw Hill, 1977

5.	Altan T. and Tekkaya A. E., Sheet metal Forming, ASM International, 2012
6.	Jiang Z., Zhao J., and Xie H., Microforming Technology, Academic Press, 2017
7.	Faraji G., Kim H. S. and KashiSevere H. T., Severe Plastic Deformation Methods, Processing and Properties, Elsevier, 2018
8.	Suwas S., and Ray R. K., Crystallographic Texture of Materials, Springer London, 2014.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the basic concepts plastic deformation
CO2	Analyze plastic deformation processes
CO3	Identify and analyze the requirement of different high velocity forming processes, micro-forming processes and severe plastic deformation processes
CO4	Interpret and evaluate crystallographic texture development by deformation processes.

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR605
Course Title	:	**Manufacturing Management**
Type of Course	:	PC
Prerequisites	:	
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To enable the students to understand the role of manufacturing management in organizational decision making
CLO2	To study the strategic, tactical and operational decision-making tools in order to model a manufacturing or a service system
CLO3	To understand the application of manufacturing management policies and techniques to the manufacturing and service organizations

Course Content

Origin of manufacturing management- Functions- Principles: Henri Fayol, F. W. Taylor- System approach- Strategic, Tactical and Operational decisions – Total quality management Supply chain management-key issues- Areas of improvement - Different flows.

Aggregate production planning- transportation and linear models – Inventory management – cost of inventory management- EOQ models-models with price breaks. Facility location models - Distribution model - Brown and Gibson model, Gravity location algorithm.

Material Requirement Planning (MRP) - working of MRP - master production scheduling - Lot sizing in MRP system- Capacity requirement planning, ERP and softwares.

Project scheduling- CPM, PERT- Sequencing and scheduling- Types of scheduling- Johnson algorithm - Branch and bound algorithm- Heuristic, Palmer's algorithm- CDS algorithm- Insertion algorithm.

Assembly Line Balancing- Line efficiency- Smoothness index - Taguchi Method- Introduction to Industry 4.0, Role of artificial intelligence and analytics in manufacturing, Industrial IOT.

References

1.	Sunil Chopra, Peter Meindl, "Supply Chain Management: Strategy, Planning and Operations", Prentice Hall India, 6th Edition, 2016
2.	Buffa, Sarin "Modern Production Management", 8th Edition, John Wiley, 2007
3.	O. Perez, S. Sauceda, J. Cruz, Manufacturing 4.0: The Use of Emergent Technologies in Manufacturing, 2018

4.	S N Chary, "Production and Operations Management", McGraw Hill, 6th Edition, 2019

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the role of manufacturing management in organizational decision making
CO2	Build and analyze quantitative models for organizational decision making
CO3	Select appropriate tools for decision making and apply tools for modelling of complex systems
CO4	Analyze the outcome and offer suggestions for improvement

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Second Semester:
Programme Core (PC):

Course Code	:	PR602
Course Title	:	**Welding and Additive Manufacturing**
Type of Course	:	PC
Prerequisites	:	
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop the skills in fusion welding techniques and various additive manufacturing processes
CLO2	To analyse the effect of process parameters on the quality of welded and additive manufactured products
CLO3	To inspect the quality of welded and additive manufactured products

Course Content

Welding: Power source characterizations**,** Electrodes and Flux classification and its characteristics, Electrode manufacturing, Fundamentals of Welding Processes - Arc Welding processes, Laser Beam Welding, Electron Beam Welding, Solid state Welding processes, Metallurgical Aspects of Welding, weld cladding, Arc welds characterization in newer materials. Basic design of weldments.

Advances in Welding: High current TIG welding Process, A-TIG welding process, Cole metal arc transfer GMAW process, Hybrid Welding Processes, spin arc GMA welding process, Pulse welding techniques, Friction surfacing, surface modification techniques, Welding Defects and Inspection Techniques, Basic Standards in welding.

Additive Manufacturing (AM): Overview of Additive Manufacturing Technologies - Powder Bed Fusion (SLM, EBM), WAAM, CMT, Directed Energy Deposition (DED), Binder Jetting, Stereo lithography systems, Fused Deposition Modelling, Laminated Object, Materials Used in Additive Manufacturing, Process Parameters and Control, Design for Additive Manufacturing (DfAM), Post-Processing and Quality Assurance.

References

1.	Ian Gibson, David Rosen, and Brent Stucker. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Springer, 2014
2.	Pham D. T. and Dimov S. S., "Rapid Manufacturing", Verlag, 2001
3.	Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME, 1996
4.	Prasad H and Badrinarayanan, K S, “Rapid Prototyping and Tooling”, SPI Pageturners Bangalore, India, 2013
5.	R. S. Parmer "Welding processes and Technology" Khanna Publishers

6.	S.V.Nadkami, Modem Arc Welding Technology, Oxford & IBH Publishing Co. Pvt. Ltd
7.	Cornu.J. Advanced welding systems – Volumes I, II and III, JAICO Publishers, 1994
8.	Lancaster. J.F. – Metallurgy of welding – George Alien & Unwin Publishers, 1980
9.	Carry B., Modern Welding Technology, Prentice Hall Pvt Ltd., 2002

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand fundamental principle of different process in welding and various additive manufacturing processes
CO2	Design and characterize the process parameters for welding and additive manufacturing processes
CO3	Inspect the quality of welded and additive manufactured products

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR604
Course Title	:	**Advanced Tooling and Automated Inspection**
Type of Course	:	PC
Prerequisites	:	
Contact Hours	:	2-1-2-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To train students in state of art of Tooling in Manufacturing
CLO2	Design and Develop flexible tooling for Manufacturing
CLO3	Design and Develop automated inspection systems

Course Content

Introduction to Principles of Tooling in Manufacturing-Economics of Tooling- Pre - Design, Product and Process Analysis –Soft and Hard Automation-Tooling for Machining-Tool Changers-Tool Presets-Flexible Tooling

Tooling for Forming- Evolution of Dies, Forging, Bending and Drawing and Extrusion Processes- Tooling for Casting processes –Mechanization -Tooling in Non-Traditional Manufacturing –Tooling for Micro Manufacturing-Tooling for Physical and Mechanical joining Processes

Tooling for CMM Principles of Gauging - New concepts for gaging, inspection, checking, machine vision, and robotic testing. Smart Inspection Systems - Techniques and Applications of Intelligent Vision -Stages of automated visual inspection (AVI) and "smart" inspection systems- AVI process, from illumination, image enhancement, segmentation and feature extraction, through to classification.

Tooling Practice in Traditional and Non-traditional Machining- Machining Centres, Turning centers, Micromachining, Mechatronics AS/RS, Robots and CMM

References

1.	Fundamentals of Tool Design, Fifth Edition Society of Manufacturing Engineers, 2003
2.	Mikell P Groover Fundamentals of Modern Manufacturing: Materials, Processes, and Systems, John Wiley and Sons, 2012
3.	Stanley L. Robinson, Richard Kendall Miller Automated Inspection and Quality Assurance, 1989, CRC Press
4.	Duc T. Pham and R J Alcock Smart Inspection Systems: Techniques and Applications of Intelligent Vision, Academic Press

Course Outcomes (CO)

At the end of the course student will be able to

CO1	State of Art in Tooling in Manufacturing and Inspection
CO2	Design and Develop tooling for modern manufacturing
CO3	Design and Develop Automated Inspection Systems

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR606
Course Title	:	**Production Automation and CNC Technology**
Type of Course	:	PC
Prerequisites	:	
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop advanced machine language for operating machine tools
CLO2	To apply computer numerical control techniques for making macro and micro products
CLO3	To understand cellular manufacturing techniques

Course Content

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

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

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

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

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

References

1.	YoramKoren, "Computer Control of Manufacturing Systems", McGraw Hill Book Co. New Delhi, 1986
2.	Mikell P. Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India, 2009
3.	Radhakrishnan P., "Computer Numerical Control Machines", New Book Agency, Calcutta, 1991
4.	Kundra T. K., Rao P. N., and Tiwari N. K., "CNC and Computer Aided Manufacturing", Tata McGraw Hill, New Delhi, 1991

5.	Fitzpatric. M., “Machining and CNC Technology”, McGraw Hill, 2004

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Develop advanced machine language for operating machine tools
CO2	Apply computer numerical control techniques for making macro and micro products
CO3	Understand cellular manufacturing techniques

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Laboratory:
First Semester:

Course Code	:	PR607
Course Title	:	**Advanced Material Processing Lab.**
Type of Course	:	ELR
Prerequisites	:	
Contact Hours	:	0-0-4-2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To teach the influence of parameters on various machining processes
CLO2	To impart the practical knowledge of metal joining processes
CLO3	To offer practical insights into metal forming techniques
CLO4	To deliver hands-on expertise in contemporary manufacturing techniques

Course Content

List of Experiments

1. Studies on laser surface modification/ treatment methods.
2. Analysis of laser joining techniques.
3. Experiments on laser micro-machining processes.
4. Tests on laser shock peening techniques.
5. Analysis of laser powder bed fusion in metal additive manufacturing.
6. Analysis of machinability and tool wear during machining processes.
7. Force / Thermal / Vibration analysis during machining processes.
8. Experiment on robotic welding processes (MIG/ WAAM, etc.)
9. Analysis of unconventional machining processes (EDM/AWJM/USM/EBM, etc.)
10. Construction and analysis of Forming Limit Diagram / Wrinkling Limit Diagram.
11. Analysis of sheet metal/ bulk metal forming processes.
12. Experiments on high energy rate forming processes.
13. Investigations on sever plastic deformation of metals.
14. Experiments on smart manufacturing solutions.
15. Calibration of instruments and machines using Contact/Non-contact devices.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the influence of parameters on various machining processes
CO2	Recognize the various metal joining techniques
CO3	Analyze the behavior of metals during deformation
CO4	Illustrate contemporary manufacturing techniques

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	2	3	3

Second Semester:

Course Code	:	PR608
Course Title	:	**Automation & CIM Lab.**
Type of Course	:	ELR
Prerequisites	:	
Contact Hours	:	0-0-4-2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To Learn the automation system using fluid power control system and its applications
CLO2	To Learn the manufacturing process simulation and generation G- codes/ M-Codes for the given part drawing
CLO3	To Learn the CNC Programming and write G-Codes/M-Codes for the given part drawing
CLO4	To Learn the Robot programming and function of ASRS

Course Content

List of Experiments

1. Exercise on hydraulic system: Design, construct and simulation of different hydraulic circuits for the given applications.
2. Exercise on Pneumatic system: Design, construct and simulation of different Pneumatic circuits for the given applications.
3. Simulation of Electro-pneumatic latch circuits / Logic pneumatic circuits / electro pneumatic sequencing circuits
4. Exercise on Electro-hydraulic system: Design, construct and simulation of different Electro- hydraulic circuits for the given applications.
5. Exercise on Electro-Pneumatic system: Design, construct and simulation of different Electro- Pneumatic circuits for the given applications.
6. Exercise on design of fluid power control circuit for real time industrial application.
7. Exercise on Manufacturing simulation and generation G-codes/M-Codes for the given Turning profile using a computer aided manufacturing software.
8. Exercise on Manufacturing simulation and generation G-codes/M-Codes for the given Milling profile using a computer aided manufacturing software.
9. Exercise on Plain turning, Step turning and facing operations on turning machine.
10. Exercise on Plain turning, Step turning, facing operations and External threading operation on STC 15 machines.
11. Exercise on Profile milling operation on VMC machine.
12. Exercise on Circular pocketing / Rectangular pocketing / drilling/ Mirroring operations on milling machine.
13. Exercise on Measurement of form tolerance (circularity, cylindricity and perpendicularity) using CMM.

References

1.	Automation & CIM Lab manual

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply fluid power control system for industrial automation
CO2	Generate G-codes/M-Codes for the given part drawing using CAD software by simulating manufacturing process
CO3	Understand and write CNC Programme: G-codes/M-Codes for the given part drawing
CO4	Write the Robot programming and understand function of ASRS

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	**PO1**	**PO2**	**PO3**
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3

Course Code	:	PR610
Course Title	:	**Process Modelling and Additive Manufacturing Lab**
Type of Course	:	ELR
Prerequisites	:	
Contact Hours	:	0-0-4-2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To perform numerical modelling of metalworking
CLO2	To develop numerical models for the analysis of the Additive Manufacturing process
CLO3	To execute product development phases
CLO4	To develop eco-friendly products

Course Content

Process Modelling Lab

1. Modelling & simulation of arc welding process
2. Modelling & simulation of pressure die casting / centrifugal casting
3. Modelling & simulation of forging/rolling/machining process
4. Microstructural modelling of forging/machining process
5. Modelling & Simulation of powder-based metal AM process
6. Modelling & Simulation of droplet-based metal AM process

Additive Manufacturing Lab

7. Product Development (Concept Design and Detailed Design using CAD).
8. Product Development (Engineering Analysis using CAE).
9. Generation of .stl files and Estimation of Additive manufacturing parameter using Slicing module
10. Product Development (fabrication using 3D printer)
11. Application of DfAM methods
12. Life Cycle Assessment of additive manufactured parts (Product/Process based)

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Model and simulate of metalworking processes
CO2	Expertise in performing simulation of metal-based AM processes
CO3	Execute product development phases
CO4	Develop environmentally friendlier products

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	2
CO2	3	2	3
CO3	3	2	3
CO4	3		3

Program Electives (PE):

Course Code	:	PR611
Course Title	:	**Modeling of Manufacturing Processes**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand numerical methods for solving non-linear problems
CLO2	To develop knowledge of numerical methods for the analysis of metal working processes
CLO3	To understand and apply mathematical and numerical models for additive manufacturing processes

Course Content

FE concepts – variational and weighted residual approaches – Element types – 2D elements – plane triangular, quadrilateral, 3-dimensional axi-symmetric, – mapping of elements – numerical problems

FE procedure for non-linear problems - Material and geometric non-linearities – solution using implicit and explicit methods – numerical problems

Lagrangean and Eulerian formulations for modeling of machining, rolling, forging, and drawing. ALE elements

Mathematical models for additive manufacturing processes- transport phenomena models -temperature, fluid flow and composition, buoyancy-driven, tension driven free surface flow - case studies

Numerical modeling of AM processes - powder bed fusion, droplet-based, residual stress, defects prediction. simulations for the selection of parameters.

References

1.	M. Asghar Bhatti “Advanced Topics in Finite Element Analysis of Structures” John Wiley & sons, Inc,2006
2.	Lewis R.W. Morgan, K, Thomas, H.R. and Seetharaman, K.N. The Finite Element Method in Heat Transfer Analysis, John Wiley, 1994
3.	Edward R Champion Jr, “Finite Element Analysis in Manufacturing Engineering”, McGraw Hill, 1992
4.	Prakash M., Dixit, Uday S. Dixit” Modeling of Metal Forming and Machining Processes”, 1st Edition, 2008, Springer Verlag
5.	Lars-Erik Lindgren, “Computational welding mechanics”, 1st Edition, 2007, CRC Press

6.	Bourell, David L., Frazier, William, Kuhn Howard, and Seifi Mohsen, ASM Handbook, Volume 24: Additive Manufacturing Processes, USA

Course Outcomes (CO)

At the end of the course student will be able

CO1	To apply and solve non-linear problems in numerical methods
CO2	To develop numerical methods for solving metal working problems
CO3	To perform mathematical and numerical models for AM Processes

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR612
Course Title	:	**Advances in Polymer Matrix Composites**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the overall view of Polymeric Matrix Composite materials
CLO2	To acquire the knowledge of different fabrication methods of Polymeric Matrix Composites material and its Characterization
CLO3	To learn the Weldability and Machinability characteristics of Polymeric Matrix Composite materials
CLO4	To select the suitable Polymeric Matrix Composite materials for industrial applications considering the Environmental issues

Course Content

Composite material: Types-MMC-PMC-CMC, Advantages and Disadvantages. Polymer matrix: classification- thermoplastics and thermosetting plastics, types of matrix material, reinforcement material: fiber- particulate- whisker, properties of reinforcements and matrix. Characterization of polymer matrix composites

Primary Manufacturing Techniques of PMC material: Lay-up process, Vacuum-Bagging Process, Autoclave Molding, Compression Moulding process, Injection moulding process, transfer moulding process, filament Winding process and Pultrusion process.

Secondary Manufacturing Techniques of PMC material: Forming methods for Polymers and polymeric composite material- component design consideration. Machinability study (turning, milling and drilling) on polymeric composite material.

Joining of PMC: Mechanical fastening of PMC, Chemical bonding of PMC, Joint design, equipment and application methods, Advantages and disadvantages, Applications adhesive bonding. Weldability study on PMC-Friction Welding, Thermal Welding, Electromagnetic Welding-Process-Processing Parameters-Materials-Advantages & Disadvantages and Applications.

Application of Polymers and PMC material: Automotive Industry- Marine Industry- Materials Handling- Chemical Industry- Electrical & Electronics Industry- Aerospace Industry- Biomedical field. Recent advancements in polymeric materials: Polymer Blends, conducting polymer, Polymeric Nanocomposites and Biodegradable Polymer-its Applications. Polymer in health care, Environmental issues concerning polymers and polymer in energy application.

References

1.	Mein Schwartz., Composite Materials Handbook, McGraw Hill, 1984
2.	ASM Hand book on Composites, Volume 21, 2001
3.	Handbook of Plastics Joining- A Practical Guide, Plastics Design Library, 13 Eaton Avenue, Norwich, New York 13815.
4.	Handbook of Polymer Composites for Engineers by Leonard Hollaway, British Plastics Federation
5.	Process Selection from design to manufacture published in 1997 by Edward Arnold

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Acquire the knowledge of the polymers matrix and reinforcement materials used in polymer matrix composites
CO2	Describe manufacturing methods and characterization of polymer matrix composites
CO3	Perform Forming, Joining & machining operation to make product from the polymer matrix composites
CO4	Select and Apply the appropriate polymer matrix composites material for recent industrial applications & confront environmental issues

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR613
Course Title	:	**Heat Treatment Processes**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify the effect of heat treatment in alloying elements
CLO2	To apply surface modification techniques
CLO3	To find the defects occurring in heat treated parts

Course Content

Iron - Carbon Equilibrium Diagram: Effect of alloying element on properties of steel and heat treatments. Types and application of heat treatments in manufacturing Industries.

TTT & CCT diagram for steels-Various heating media used for heat treatment, furnaces, Temperature and atmosphere control- Selection of furnace for heat treatment.

Heat Treatment Processes: Annealing – Normalising, Hardenability studies, Jominy end quench test, Grossman's experiments - Tempering, Austempering and Martempering. Thermomechanical treatments.

Surface Modification Techniques: Induction hardening, flame hardening, electron beam hardening and Laser beam hardening. Carburising, nitriding, carbonitriding, CVD and PVD processes, Ion implantation.

Heat Treatment of Specific Alloy steels: Heat treatment of gray irons, white irons (malleabilising) and S.G.irons. Austempering of S.G.Iron. Heat Treatment of Non-Ferrous Metals, Defects: Defects in heat treated parts, causes and remedy Design for heat treatment.

References

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

	edition 1984
6.	Novikov I, "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the effect of heat treatment in alloying elements
CO2	Apply surface modification techniques
CO3	Find the defects occurring in heat treated parts

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR614
Course Title	:	**Industrial Welding Applications**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply the knowledge of welding in Heavy Engineering
CLO2	To apply the knowledge of welding in Automotive Industries
CLO3	To apply the knowledge of welding in Nuclear Power

Course Content

Application of welding in heavy engineering: Boiler manufacture - boiler drum, water wall panels, headers, economizers. Heat exchangers.

Application of welding in oil & gas industries: orbital pipe welding, welding consumables, fabrication codes, inspection &testing, acceptance criteria.

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

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

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

References

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

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply the knowledge of welding in Heavy Engineering
CO2	Apply the knowledge of welding in Automotive Industries
CO3	Apply the knowledge of welding in Nuclear Power

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR615
Course Title	:	**Laser Material Processing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamental properties of laser beams as advanced materials processing and manufacturing tool
CLO2	To describe the various types of operation in laser surface treatment, welding, cutting and drilling of different materials
CLO3	To develop skills necessary to effectively analyse laser based physical processes and their implications in material processing and manufacturing processes

Course Content

Fundamentals of laser - Characteristics – Lasing action - laser components – Modes of operation- Types of laser – Applications: Materials Processing – Spectroscopy - Photochemistry – Nuclear fusion – Defence – Medical - Industrial - Interaction of laser radiation with materials-Long pulse and short pulse machining

Laser surface Engineering and Welding – Forms of Surface treatment - Laser transformation hardening - Laser surface melting - Laser alloying - Laser cladding – Laser surface texturing – Laser shock peening – Laser shock loading - Case examples. Laser welding – Modes of welding - Operating characteristics - Process variations - Applications and Case Example.

Laser Cutting and Drilling - Methods of cutting - Vaporization cutting - Fusion Cutting - Reactive Fusion Cutting - Controlled Fracture – Scribing – Cold cutting - Operating characteristics - Applications - Process variations. Laser drilling – Types – Single-pulse drilling - Percussion drilling – Trepanning – Helical Drilling - Applications – Case Example.

Laser Marking and Micromachining – Forms of Laser Marking - Raster Marking – Vector Marking – Marking with mask - Fiber Laser and UV Laser based marking - Micromachining solutions - automotive - electronic - food - jewellery - medical - Laser safety standards.

Laser Additive Manufacturing – Classification - Stereo lithography (SL) Selective Laser Sintering (SLS) - Selective Laser Melting (SLM) - Direct Metal Deposition (DMD) – Process variations – Applications – Case Example.

References

1.	William M. Steen, “Laser Material Processing”, Springer Verlag, 2010
2.	M. Young, “Optics and Lasers”, Springer, 2013
3.	J.F. Reddy, “Industrial Applications of Lasers”, Academic Press, New York, 1978
4.	Michael Bass, “Laser Materials Processing”, Elsevier Science, 1983
5.	Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani, “Additive Manufacturing Technologies”, Springer, 2020

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Compare the types of lasers and its applications
CO2	Employ laser for surface engineering, welding, cutting and drilling
CO3	Analyse the micro machining processes by Laser

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR616
Course Title	:	**Machine Tool Technology**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Identify various parts of machine tools
CLO2	Apply various design aspects of spindles and bearings
CLO3	Reduce vibration and chatter developing on machine tools

Course Content

Metal cutting machine tools and their specifications - machine beds and columns - relative merits of different types of beds and columns - design of beds and columns - force on cutting tool.

Types of slideways and design of slideways - wear adjustments in slideways, surface treatment for slideways.

Design of spindles – example for lathe, drilling machine and milling machine, Design of bearing- example for lathe, drilling machine and milling machine, choice of bearings.

Types of drives for machine tool – step and stepless – speed and feed mechanisms – kinematic diagrams. Typical examples for drives in advanced machine tools.

Machine tool vibration – types - effect of undeformed chip thickness variations, rake and clearance angle variations - stability of cutting operation - regenerative chatter - testing of machine tools for alignment and accuracy - standard test charts

References

1.	Sen and Bhattacharya, “Principles of Machine Tools”, New Central Book Agencies, 1975
2.	Boothroyd,G., “Fundamentals of Metal Machining and Machine Tools”, McGraw Hill, 1985
3.	Acherkan, “Machine Tool Design”, Vol. 2 & 3, MIR Pub, 1973

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify various parts of machine tools
CO2	Apply various design aspects of spindles and bearings
CO3	Reduce vibration and chatter developing on machine tools

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR617
Course Title	:	**Manufacturing of Non-Metallic Products**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To describe the types of polymers, rubbers and its manufacturing techniques
CLO2	To describe the application, types of glass and ceramics and their manufacturing methods
CLO3	To understand the knowledge in types of composites and their manufacturing techniques

Course Content

Introduction to engineering materials – properties of non-metals - Polymers - classification- Thermoplastics and thermosetting plastics - Thermoforming processes - compression and transfer molding - injection molding - extrusion - blow molding - calendaring – reaction injection molding – rotational molding - lamination and pultrusion.

Rubber - additives - applications. Stages in raw rubber and latex rubber technology - Processing of rubbers –Manufacturing techniques - tires - belts - hoses - foot wears - cellular products - cables. Manufacture of latex based products.

Glass - characteristics - application - glass making - Glass forming machines - hollow wares flat glasses, fiberglass, bulbs, bottles, heat absorbing glasses, amber glass and their manufacturing methods, general plant layouts for manufacture of different types of glasses.

Ceramics - classification - traditional ceramics - structural ceramics - fine ceramics - bio ceramics - ceramic super conductors. Ceramic powder preparation - Ceramic processing techniques - hot pressing - hot isostatic pressing (HIP) - Sintering - injection molding - slip casting - tape casting - gel casting - extrusion.

Composites – types and manufacturing methods: hand lay-up – autoclaving - filament winding - pultrusion - compression molding – preparation of molding compounds and prepregs - sheet molding - casting - solid state diffusion - cladding - HIP - liquid metal infiltration – sintering and its types - knitting - braiding.

References

1.	Manufacturing Processes for Engineering Materials: S. Kalpakjian, 5th edition Pearson, 2009
2.	Plastic Materials and Processing: A. Brent Strong, Prentice Hall, 2006
3.	Composite Materials: Engineering and Science: F.L. Mathews and R.D.

	Rawlings, CRC press, 1999
4.	Premamoy Ghosh, Polymer Science and Technology – Plastics, Rubber, Blends, and Composites, 3rd Edition, Mcgraw hill, 2011
5.	ASM Handbook, Vol. 21 Composites, 2001 Lubin, Handbook of Composites, Springer, 1st Edition, 1982.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the types of polymers, rubbers and its manufacturing techniques
CO2	Describe the application, types of glass and ceramics and their manufacturing methods
CO3	Knowledge in types of composites and their manufacturing techniques

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR618
Course Title	:	**Mechanical Behaviour of Materials**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand structure and deformation mechanics of materials
CLO2	To understand strengthening mechanisms
CLO3	To identify different modes of failure of materials
CLO4	To evaluate mechanical properties of different materials

Course Content

Introduction: Overview on elastic and plastic behavior, and structure of materials; Isotropic and anisotropic properties of cubic and noncubic crystals.

Crystal plasticity: dislocation geometry and energy, dislocation mechanics, crystal defects, slip system, hardening, yield surface, micro-to-macro plasticity; Strain-rate and temperature dependence of flow stress; Mechanical Twining, Martensitic transformation, Shape memory and superelasticity; Strengthening mechanism of metals.

Material testing: tensile test, hardness test, fatigue, creep and impact testing; Heat treatment; Concept of fatigue, fracture, creeps and stress rupture; Embrittlement and residual stress.

Mechanical behavior of Ceramics, glasses, polymeric materials, Deformation behavior of metal sandwich materials and metal-matrix composite material, Rheological behavior, and Viscoelasticity.

References

1.	William F. Hosford, Mechanical Behaviour of Materials, Cambridge University Press, New York, USA, 2005
2.	Marc A. Meyers and Krishan Kumar Chawla, Mechanical Behaviour of Materials, 2nd revised eds, Cambridge University Press, New York, USA, 2008
3.	Dieter, G. E., “Mechanical Metallurgy”, 3rd Ed., McGraw Hill. 1988
4.	Courtney, T.H., “Mechanical Behavior of Materials”, 2nd Ed., McGraw Hill. 1990
5.	Meyers, M.A. and Chawla, K.K., “Mechanical Behavior of Materials”, Prentice Hall. 1999
6.	R.W.K., “The Plastic Deformation of Metals”, Edward Arnold
7.	D.W.A. Rees, Basic Engineering Plasticity, Elsevier India, New Delhi, 2008
8.	John D. Verhoeven, Fundamentals of Physical Metallurgy, Wiley, 1975
9.	Robert E. Reed-Hill, Physical Metallurgy Principles, 2nd Editions, East-West

	Press Pvt. Ltd, New Delhi, 2008

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand structure and deformation mechanics of materials
CO2	Understand strengthening mechanisms
CO3	Identify different modes of failure of materials
CO4	Evaluate mechanical properties of different materials

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	**:**	PR619
Course Title	**:**	**Mechanics of Composite Materials**
Type of Course	**:**	PE
Prerequisites	**:**	
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To classify the composite materials
CLO2	To categorize the properties of composite materials
CLO3	To apply the knowledge of matrix in composite materials

Course Content

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

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

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

Manufacturing processes and Quality assurance of composites.

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

References

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

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Classify the composite materials
CO2	Categorize the properties of composite materials
CO3	Apply the knowledge of matrix in composite materials

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR620
Course Title	:	**Non-Destructive Testing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge on various inspection techniques available to check weld quality
CLO2	To develop the knowledge on the selection of appropriate Non-destructive techniques

Course Content

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

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

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

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

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

References

1.	American Metals Society, "Non-Destructive Examination and Quality Control" Metals Hand Book, Vol. I 7, 9th Ed, Metals Park, OH, 198
2.	Krautkramer, Josef and Hebert Krautkramer, "Ultrasonic Testing of Materials", 3rd Ed, Newyork, Springer-verlag, 1983
3.	Goswami,"Thin film fundamentals", New age international (P) Ltd. Publishers, New Delhi, 1996
4.	Birchan, D, "Non-Destructive Testing", Oxford University Press, 1977

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Select appropriate non-destructive techniques
CO2	Apply surface modification techniques
CO3	Compare the merits of various non-destructive techniques

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR621
Course Title	:	**Smart Materials and MEMS**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To describe the overview of different kinds of smart materials and their applications
CLO2	To describe the various fabrication processes of smart materials and MEMS
CLO3	To deliberate the fundamentals of mechanics for design of smart materials

Course Content

Introduction to smart materials and MEMS: an overview- scaling issues in MEMS - Micro sensors – Micro actuators – Micro systems – Examples of smart systems.

Smart composites - piezoelectric materials, shape memory alloys, magnetic materials - Electro and magneto-statics, Electro active polymers and electrostrictive materials - measurement techniques for MEMS.

Fabrication processes - Structure of silicon and other materials Silicon wafer processing; Thin film deposition, Lithography, Etching, LIGA, Micromachining, Thick-film processing.

Mechanics of materials- Stresses and deformation: bars and beams - Micro device suspensions: lumped modeling -Residual stress and stress gradients - Thermal loading; bimorph effect - Vibrations of bars and beams - Gyroscopic effect.

Electronics and packing - Semiconductor devices - Signal conditioning for microsystems devices-Vibration control of a beam - Integration of microsystems and microelectronics - Packaging of microsystems.

References

1.	Engineering analysis of smart material systems, Donald J. Leo, John Wiley Sons
2.	Smart material systems: model development, R.C. Smith, SIAM
3.	S.D. Senturia, Microsustem Design, Kluwer Academic Publishers, 2001
4.	Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, McGraw Hill, 2002
5.	V.K. Varadan, K.J. Vinoy, and S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, Wiley, 2006

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the overview of different kinds of smart materials and their applications
CO2	Describe the various fabrication processes of smart materials and MEMS
CO3	Deliberate the fundamentals of mechanics for design of smart materials

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	**PO1**	**PO2**	**PO3**
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR622
Course Title	:	**Surface Engineering**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To compare the use of different surface engineering techniques
CLO2	To select appropriate thermal process to alter the material surface
CLO3	To apply laser for surface modification

Course Content

Introduction- Significance of surface engineering- Solid surface- Surface energy- Superficial layer- Physico-chemical parameters- Properties of the superficial layer- Surface coating- Classification.

Physical vapor deposition (PVD): Ion plating- Sputter deposition- Reactive deposition- Magnetron sputtering- Chemical vapor deposition (CVD)- Ion implantation- Electron beam technology- Applications.

Thermal Spraying Techniques- Flame Spraying, Atmospheric Plasma Spraying (APS), Vacuum Plasma Spraying (VPS), Detonation-Gun Spraying (D-GUN), High-Velocity Oxy- Fuel (HVOF) Spraying-Applications.

Laser surface engineering- Laser transformation hardening - Laser remelting- Laser alloying- Laser cladding- Laser ablation- Pulsed laser deposition- Laser doping - Laser crystallization- Laser surface texturing- Laser shock peening.

Methods of characterization-Microstructure- Mechanical: Adhesion-Hardness-micro hardness- Residual Stress-Friction-Wear- Physical: Porosity-Density- Electrical: Conductivity- Magnetic- Chemical.

References

1.	Tadeusz Burakowski, Tadeusz Wierzchon, “Surface Engineering of Metals- Principles, equipment and technologies”, CRC Press, 1999
2.	Lech Pawlowski, "The Science and Engineering of Thermal Spray Coatings", 2nd Edition, John Wiley & Sons, 2008
3.	William M. Steen, Jyotirmoy Mazumder, “Laser Material Processing”, 4th Edition, Springer Verlag, 2010

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Compare the use of different surface engineering techniques
CO2	Select appropriate thermal process to alter the material surface
CO3	Apply laser for surface modification

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR623
Course Title	:	**Tribology**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the importance of friction, wear and lubrication of contacting surfaces
CLO2	To understand the mechanism of different forms of wear
CLO3	To describe the various forms of lubrication
CLO4	To measure the Micro/ Nano technology using industrial applications

Course Content

Industrial significance of tribology - Service life - Role of elastic deformation - Plasticity index - Practical objectives of tribology - Physio-chemical characteristics of solid surfaces - Analysis of surface roughness - Lubrication to reduce friction – Case example

Classification of friction - Static and kinetic friction - Dry friction – Laws - Scientific explanation - Theory of adhesive friction - Friction due to deformation - Ploughing due to spherical asperity - Rolling friction – Sources - Friction measuring systems - Force measuring devices - Stick-slip - Nature-Inspired Friction

Wear mechanisms - Abrasive wear - Adhesive wear - Laws of adhesive wear - Archard's Wear Equation - Erosive wear – Cavitation, Corrosive, Fatigue, Fretting, Oxidative Wear - Wear due to electrical discharges – Melting, Diffusive, Impact wear - Wear of non-metallic materials – Polymers – FRP – Ceramics - Nature-Inspired Wear

Lubrication mechanisms - Boundary Lubrication - Mixed Lubrication - Elasto-hydrodynamic lubrication - Hydro Dynamic Lubrication - Tower's experiment - Fluid mechanics concept – Viscosity - Hydrostatic Lubrication - Types of Lubricants - Lubricant additives - Nature-Inspired Lubrication

Micro/nano tribology - Friction at atomic scale - Friction at micro scale - Length Scale dependence - Wear mechanisms - Measurement techniques – STM – AFM - Nanomechanical properties of solid surfaces - Nano indentation – SAM - Micro/Nanotribology of MEMS/NEMS – AM based on Nanotribology

References

1.	I.M. Hutchings, "Tribology: Friction and Wear of Engineering Materials", Elsevier Limited, 1992
2.	G. W. Stachowiak, A. W. Batchelor, "Engineering Tribology", Elsevier Limited,

	2005
3.	K.C. Ludema, “Friction, wear, lubrication: A text book in tribology”, CRC Press, 1996
4.	Bharat Bhushan, “Principles and applications of tribology”, John Wiley & Sons, 1999
5.	Bharat Bhushan, “Nanotribology and Nanomechanics: An Introduction”, Springer, 2008

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply the knowledge of tribology in industries
CO2	Identify the friction and its effect
CO3	Analyse wear of different forms

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR624
Course Title	:	**Friction Materials**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide a comprehensive idea regarding the friction materials and its performance
CLO2	To explore various ingredients and fabricate different types of friction composites
CLO3	To demonstrate knowledge of various industrial standards for testing the friction composites
CLO4	To identify the difference between OE and after-market friction materials

Course Content

Introduction and Classification of Friction Materials: Introduction- Friction- Types of Friction- Laws of friction- Wear- Types of Wear- Mechanism. Friction Materials: Definition- Broad Classification- Organic Friction Materials- Ceramic Friction Materials- Sintered Friction Materials- Application oriented Friction Composites & Types-OE and aftermarket products

Ingredients & Manufacturing: Raw Materials- Classification of raw materials: Fillers, Binders, Friction Modifiers, Structural Reinforcement- Characteristics of raw materials- Laws governing the choosing of raw materials- Manufacturing Process involved in the development of composites- Case studies on the issues faced during the manufacturing and quality inspection of manufacturing component

Quality Assurance Characterizations: Introduction- Types- Physical, Chemical, Mechanical, Thermal Characterization- Indian and Global standards involved in the testing of friction materials- Case studies and calculations

Tribological Characterizations: Introduction- Overview of testing- Screening tests- Simulated conditions tests- Field testing- Documentation and interpretation of results- Case studies on the problems faced during real-time testing

Inspection and Field Case Studies: Introduction- Surface Characterization- SEM-Elemental Mapping- XRD analysis- Surface Roughness (AFM/3D interferometer)- Case studies on problems affecting the performance

References

1.	ASM Handbook, Friction, Lubrication, and Wear Technology, Volume 18, 1992, USA
2.	Peter J. Blau, Friction Science and Technology- From Concepts to Applications,

	Second Edition, 2009, CRC Press, USA
3.	HO Jang, Chapter Title: Brake Friction Materials, Book Title: Encyclopedia of Tribology, pp 263-273, 2013, Springer US
4.	Jayashree Bijwee, Chapter 17: Multifunctionality of non-asbestos organic brake materials, Book Title: Multifunctionality of Polymer Composites: Challenges and New Solutions, pp 551- 570, 2015, Elsevier, USA
5.	K. L. Sundarkrishnaa, Friction Material Composites: Materials Perspective, 2013, Springer, ISBN: 3642334504

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Provide a comprehensive idea regarding the friction materials and its performance
CO2	Explore various ingredients and fabricate different types of friction composites
CO3	Demonstrate knowledge of various industrial standards for testing the friction composites
CO4	Identify the difference between OE and after-market friction materials

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR625
Course Title	:	**Advanced Casting Processes**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of advanced casting processes
CLO2	To enable the students to understand the gating system design, die/pattern design and mechanization of foundry
CLO3	To enable the students to understand the Solidification of ferrous and non-ferrous alloys
CLO4	To enable the students to understand the Modern molding and core making processes and equipment's
CLO5	To enable the students to understand the Special Casting processes

Course Content

Trends & scope in casting Industry: Position of casting industry worldwide and in India, analysis of data in respect of production and demand, recent trends in quality specifications like dimensional accuracy, surface finish and property requirements, specifications, properties and applications of modern cast alloys- SG iron. Al – alloys, Mo- alloys, Ti – alloys.

Design considerations in manufacturing of patterns and dies: Computer Aided pattern design and manufacture, pattern making machines and equipments, Computer aided design of dies in die casting and centrifugal casting, materials used and allowances in patterns and dies. Design of gating system: Elements and types of gating systems, gating ratio pressurised & unpressurised gating, systems-applications, Risers – types and functions of risers, directional solidification – factor affecting and significance, use of exothermic sleeves, bricks, chills and their types, types and uses of filters, computer aided design for gating and risering systems.

Principles of Solidification: Nucleation kinetics, fundamentals of growth, solidification of single- phase alloys, solidification of eutectic alloys, solidification of peritectics. Melting practices and furnaces for ferrous and non- ferrous alloys: Melting practices of Al- alloys, Mg – alloys, Cu – based alloys and Ti- based alloys and SG Iron; Degassing process and methods in Al – alloys, modification treatment in Al- alloys, use of covering fluxes to avoid oxidation; Furnaces used - oil and gas fired furnaces, induction furnaces, vacuum melting and re-melting processes; Principle of working of thermocouples, spectrometers, and C.E. meters – applications; energy saving in melting practices.

Modern molding and core making processes and equipments: Various types of sands used for moulding and core making, testing of sand, high pressure line molding, Dissamatic, chemically bonded sands; shell molding binder, hardener and type of sand used in shell molding, procedure used for making shell sand, plants used, properties and tests on shell sand, stick point strength, advantages and applications; Resin bonded sands, alkyl resins, phenolic resins and furnace sands, cold box method of core making – advantages and applications, ceramic molding, vacuum molding, sand reclamation – importance, methods and plants.

Special Casting processes: Investments casting processes and applications; Continuous casting, principle, processes and applications; Die casting, low pressure / gravity, pressure and squeeze, advantages, limitations and applications, centrifugal casting, calculations of various parameters in centrifugal casting, die temperature, rotational speeds, advantages, limitations and applications of centrifugal casting, defects in centrifugal casting.

References

1.	Principles of Metal Castings - Heine, Loper and Rosenthal (TMH)
2.	Principles of Foundry Technology - P.L. Jain (TMH)
3.	Advanced Pattern Making – Cox I.I. (The Technical Press, London.)
4.	Metal Castings – Principles & Practice - T.V. Ramana Rao. (New Age International Pvt. Ltd. Publishers.)
5.	Mechanization of Foundry Shops – Machine Construction - P.N. Aeksenov (MIR)
6.	Fundamentals of Metal Casting Technology - P.C. Mukherjee (Oxford, IBH)
7.	Foundry Engineering – Taylor, Fleming & Wulff (John Wiley)

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Design of appropriate casting system to make components in industry
CO2	Identify and select suitable casting process to make components in industry

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3

Course Code	:	PR626
Course Title	:	**Computational Methods in Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of numerical methods, statistical and optimization tools
CLO2	To apply the numerical, statistical and optimization concepts and procedure for engineering problems
CLO3	To learn basic MATLAB codes for solving numerical and statistical problems

Course Content

Review of ODEs; Laplace & Fourier methods, series solutions, and orthogonal polynomials. Sturm-Lowville problem. Review of 1st and 2nd order PDEs. Linear systems of algebraic equations. Gauss elimination, LU decomposition etc., Matrix inversion, ill- conditioned system

Numerical Eigen solution techniques (Power, Householder, QR methods etc.). Numerical solution of systems of nonlinear algebraic equations; Newton-Raphson method. Numerical integration: Newton-Cotes methods, error estimates, Gaussian quadrature

Numerical solution of ODEs: Euler, Adams, Runge-Kutta methods, and predictor-corrector procedures; stability of solutions; solution of stiff equations. Solution of PDEs: finite difference techniques.

Probability and Statistics – Probability Distribution, Bays Theorem, Parameter Estimation, Testing of Hypothesis, Goodness of Fit.

Introduction to optimization methods: Local and global minima, Line searches, Steepest descent method, Introduction to heuristic techniques. Introduction to MATLAB programming

References

1.	Steven C. Chapra, Numerical Methods for Engineering, Mc-Graw Hill Education
2.	Schilling R.J and Harris S L, “Applied Numerical Methods for Engineering using MatLab and C”, Brooks/Cole Publishing Co., 2000
3.	Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press
4.	Hines, W.W and Montogomery, “Probability and Statistics in Engineering and Management Studies”, John Willey, 1990

5.	Deb Kalyanmoy, "Optimization for Engineering Design: Algorithms and Examples" Prentice-Hall of India Pvt.Ltd, 10th edition, 2009

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply the numerical concepts and techniques for manufacturing engineering problems
CO2	Understand and apply the statistical techniques in manufacturing processes
CO3	Apply optimization tools for manufacturing problems

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR627
Course Title	:	**Additive Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the importance of time compression technologies
CLO2	To selection of appropriate technology for the application
CLO3	To explore RP software packages

Course Content

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

Principle, process parameters, process details and applications of various RP processes - Stereo lithography systems, Laser Sintering, Fused Deposition Modeling, Laminated Object

Manufacturing, Solid Ground Curing, Laser Engineered Net Shaping, 3D Printing, Laser Melting, Cladding.

Rapid Tooling: Indirect rapid tooling Direct rapid tooling, soft tooling Vs hard tooling, Rapid Manufacturing Process Optimization- Factors influencing accuracy, data preparation errors, part building errors, errors in finishing, influence of part build orientation.

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

RP Technology selection, Decision Making, Life Cycle Assessment of RP processes, Sustainability issues.

References

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

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the importance of time compression technologies
CO2	Selection of appropriate technology for the application
CO3	Exposure to RP software packages

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR628
Course Title	:	**Micro/Nano Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles of various micro and nano manufacturing processes
CLO2	To study various machine tools and techniques
CLO3	To study recent developments in micro and nano manufacturing
CLO4	To understand various measuring techniques used for micro/nano components

Course Content

Introduction to meso, micro and nano manufacturing- miniaturization and applications – micro-manufacturing – classification – micro-machining: concepts and significance- theory of micro-machining – chip formation -size effect in micro-machining.

LIGA, micro-stereolithography – micro-turning, micro-drilling, micro-milling, diamond turn machining - electric discharge micro-machining-ultrasonic micro-machining-laser beam micro-machining - elastic emission micro machining – focused ion beams micro- machining.

Abrasive flow finishing, magnetic abrasive finishing, magnetorheological finishing, magnetorheological abrasive flow finishing, magnetic float polishing – Hybrid finishing processes-chemo mechanical polishing, electro discharge grinding, electrolytic in process dressing grinding.

Introduction – classification – principles, advantages limitations and applications-stereolithography – selective laser sintering – FDM, SGC, LOM, 3D printing - Surface modification techniques: sputtering-CVD-PVD-plasma spraying technique - diffusion coatings - pulsed layer deposition.

Metrology for micro machined components - optical microscopy, white light interferrometry, micro CMM, scanning probe microscopy – scanning electron microscope, transmission electron microscope, atomic force microscope

References

1.	Jain, V.K “Introduction to Micro-machining”, Narosa publishing house, ISBN: 978-81- 7319-915-8, 2010
2.	Jain, V.K, “Micro-manufacturing Processes”, by CRC Press, ISBN: 9781439852903, 2012

3.	Madou, M.J., “Fundamentals of Micro-fabrication: The science of miniaturization”, CRC Press, 2006
4.	Mcgeoug.J.A., “Micromachining of Engineering Materials”, CRC Press, 2001
5.	Kalpakjian.S, “Manufacturing Engineering and Technology”, Pearson Education, 2001

Course Outcomes (CO)

At the end of the course student will be able

CO1	Principles of various micro and nano manufacturing processes
CO2	Various machine tools and techniques
CO3	Recent developments in micro and nano manufacturing
CO4	Various measuring techniques used for micro/nano components

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR629
Course Title	:	**Design for Additive Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the scope of DfAM
CLO2	To gain competence on DfAM methods/tools
CLO3	To apply DfAM concepts to industrial products

Course Content

Introduction to Design for Additive Manufacturing (DfAM): Introduction to DfAM, Design freedom with AM, Need for Design for Additive Manufacturing (DfAM), General
Guidelines for DfAM, Design to Minimize Print Time, Design to Minimize Post-processing.

Design Guidelines for Part Consolidation: Design for Function, Material Considerations, Assembly Considerations, challenges with part consolidation. Design for Improved Functionality: Multi scale design for Additive manufacturing, Mass customization, Generative design, Design of multi-materials and functionally graded materials.

Design for Minimal Material Usage: Topology Optimization, performing analysis for weight reduction, maximize stiffness, minimize displacement, Post-processing and Interpreting Results, Applications of TO, TO tools, Design of cellular and lattice structures, Design of support structures.

Design for Polymer AM: Anisotropy, Wall Thicknesses, Overhangs, Support Material, Accuracy, Tolerances, Layer Thickness, Resolution, Print Orientation. Design for Metal AM: Powder Morphology, Powder Size Distribution, Material Characteristics, Designing to Minimize Stress concentrations, Residual Stress, Overhangs, shrinkage, warpage and Support Material.

Use Cases and Applications of DfAM: DfAM and Design Engineer, Use Cases of Designing for Additive Manufacturing, Applications of DfAM. Considerations for Analysis of AM Parts, Surface Finish, Geometry, Simplifying Geometry.

References

1.	Martin Leary, Design for Additive Manufacturing, 2019, Elsevier Science
2.	Roland Lachmayer, Tobias Ehlers, René Bastian Lippert, Design for Additive Manufacturing, 2024, Springer
3.	Olaf Diegel, Axel Nordin, Damien Motte, A Practical Guide to Design for Additive

	Manufacturing, 2020, Springer
4.	Marco Mandolini, Paolo Cicconi, Patrick Pradel, Design for Additive Manufacturing Methods and Tools, 2022, MDPI AG

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand DfAM concepts
CO2	Expertise in DfAM methods/tools
CO3	Competence to apply DfAM methods to industrial products

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3		3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR630
Course Title	:	**Computer Aided Design and Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To define the principles of optimum design
CLO2	To apply surface modelling techniques
CLO3	To analyze production systems at operation level

Course Content

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

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

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

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

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

References

1.	Radhakrishnan P & Kothandaraman C.P, “Computer Graphics and Design”, Dhanpat Rai& Sons, 1990
2.	Groover M P, “Automation, Production System and Computer Aided Manufacture”, Prentice Hall, 1984
3.	William M Newman & Robert Sproul, “Principle of Interactice Computer Graphics”, McGraw Hill, 1984
4.	Ibrahim Zeid, “CAD/CAM Theory and Practice”, McGraw-Hill, 1991

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Define the principles of optimum design
CO2	Apply surface modelling techniques
CO3	Analyze production systems at operation level

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	**:**	PR631
Course Title	**:**	**Control of Manufacturing Processes**
Type of Course	**:**	PE
Prerequisites	**:**	
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply and interfere the application of statistical methods in manufacturing processes
CLO2	To identify the causes of process variation through statistical process control
CLO3	To apply the experimental design concepts in manufacturing process for problem solving

Course Content

Review of probability and statistic distributions used in manufacturing processes. Statistical process control and process capability analysis

Mechanical process variation – analyzing the causes and interpreting data Alternate SPC methods for manufacturing process control

Application of experimental design in manufacturing

Full factorial models, Response surface modeling and process optimization, Analysis of Process robustness, Case studies

References

1.	Montgomery, Douglas C. Introduction to Statistical Quality Control. 5th Ed. New York, NY: Wiley, 2004
2.	Montgomery, Douglas C. Design and Analysis of Experiments. 5th Ed. New York, NY: Wiley, 2004.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply and interfere the application of statistical methods in manufacturing processes
CO2	Identify the causes of process variation through statistical process control
CO3	Apply the experimental design concepts in manufacturing process for problem solving

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR632
Course Title	:	**Design for Manufacture**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply various design rules in manufacturing processes
CLO2	To evaluate the process by design guidelines for optimum design
CLO3	To analyze design alternatives in the manufacture of components

Course Content

Introduction – Need identification - Design process - General Design rules for manufacturability – DFX - basic principles for economical production - creativity in design. Materials: Selection of materials for design developments in material technology - criteria for material selection – selection of material shapes.

Review of various manufacturing processes, design for casting - general design considerations for casting - casting tolerances – product design rules for sand casting – Design for bulk deformation processes – Design for sheet metal processes.

Design for Powder Metallurgy – Design for polymer processing - General design rules for machining - Dimensional tolerance and surface roughness - Design for machining.

Design for assembly - Review of assembly processes – Design for liquid state welding – Design for solid state welding – Design for soldering and brazing – Design for adhesive bonding – Design for joining of polymers - design for heat treatment.

Design for Reliability and Quality – failure mode effect analysis – Design for quality – Deishg for reliability – Approach to robust design – Design for optimization – Case studies- Redesign for manufacture and case studies: Identification of uneconomical design - Modifying the design.

References

1.	Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992
2.	Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2nd Ed. 2000
3.	Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst & Winston Ansthony Knight/CRC Press/2010
4.	James G. Bralla, "Hand Book of Product Design for Manufacturing", McGraw Hill Co, 1986

5.	Design for Manufacturing-Carrado poli-Elsevier Science and Technology Books-2001

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Apply various design rules in manufacturing processes
CO2	Evaluate the process by design guidelines for optimum design
CO3	Analyze design alternatives in the manufacture of components

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR633
Course Title	:	**Manufacturing Automation and Mechatronics**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify the various types of control valves
CLO2	To apply PLCs in circuits
CLO3	To select appropriate hydraulic and pneumatic circuits

Course Content

Need for Automation, Hydraulic & Pneumatic system Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatics system – Selection criteria. Hydraulic system components selection and specification-characteristics – Linear actuator–construction. Reservoir capacity, heat dissipation, accumulators - standard circuit symbols, circuit (flow) analysis. Direction, flow and pressure control valves-operating-characteristics- electro hydraulic servo valves-types, characteristics and performance.

Typical industrial hydraulic circuits-Design methodology – Ladder diagram-cascade, method- truth table-Karnaugh map method-sequencing circuits-combinational and logic circuit.

Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram.

Programmable logic control of Hydraulics and Pneumatics circuits, Sensors, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. Electronic drive circuits for various Motors.

Semi automats-automats-transfer lines - automatic assembly - transfer devices and feeders- classifications and applications-job orienting and picking devices- setting of automats and transfer lines.

References

1.	Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
2.	Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
3.	Dudbey.A.Peace, Basic Fluid Power, Prentice Hall Inc, 1967
4.	Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd., London, 1979
5.	E.C.Fitch and J.B. Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978

6.	W.Bolton, Mechatronics, Electronic control systems in Mechanical and ElectricaEngineering Pearson Education, 2003
7.	Peter Rohner, Fluid Power Logic Circuit Design, Mcmelan Prem, 1994

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the various types of control valves
CO2	Apply PLCs in circuits
CO3	Select appropriate hydraulic and pneumatic circuits

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR634
Course Title	:	**Product Design and Development**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To recognize the trends in product development processes
CLO2	To execute various phases of product development
CLO3	To design eco friendlier products

Course Content

Product development process – various phases, Reverse engineering and redesigning product development process, Illustrations of product development process, S-curve, new product development.

Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality. Tear Down and Experimentation, product portfolios.

Generating Concepts- Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis, concept selection, technical feasibility, ranking, measurement theory.

Robust design, Design for Manufacture and Assembly, Axiomatic design, TRIZ, Value Engineering, Industrial design, Poka Yoke – Lean principles – Six sigma concepts.

Design for the Environment: DFE methods, life cycle assessment, weighted sum assessment method, techniques to reduce environmental impact – disassembly, recyclability, remanufacturing regulations and standards.

References

1.	Kevin Otto and Kristin Wood, ―Product Design – Techniques in Reverse Engineering and New Product Development‖, Pearson Education, 2004
2.	Karl T Ulrich and Steven Eppinger, ―Product Design and Development‖, McGraw Hill, 2011, Fifth Edition

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the challenges and advancements of product development process
CO2	Execute various phases of product development
CO3	Develop environmentally friendly products/processes

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR635
Course Title	:	**Robotics**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify the components of a robot
CLO2	To program robots for different applications
CLO3	To introduce robots in various in various manufacturing techniques

Course Content

Fundamentals of robotics – wrists design - end effectors – actuators - modular robots.

Robot and its peripherals - sensors, machine vision - image processing & analysis - application of artificial intelligence, voice communication - robot control units - motion controls.

Robot kinematics - homogeneous transformations - forward & inverse kinematics - problems of dynamics - differential relationships - motion trajectories - dynamics of a robot control of single & multiple link robot - static force analysis.

Robot Programming - different languages - expert systems.

Robot applications in manufacturing - material transfer & machine loading/unloading - processing operations – inspection - automation - robot cell design – control – recent developments and special applications-Micro & Bio robotics.

References

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

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the components of a robot
CO2	Program robots for different applications
CO3	Introduce robots in various in various manufacturing techniques

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR636
Course Title	:	**Terotechnology**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To increase the reliability of a system
CLO2	To conduct reliability analysis
CLO3	To identify appropriate models for reliability measurement

Course Content

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

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

Component reliability and Hazard Models – Nonlinear hazard model Redundancy Techniques in System Design- Vibration analysis.

System reliability – Types, Fault Tree Analysis.

References

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

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Increase the reliability of a system
CO2	Conduct reliability analysis
CO3	Identify appropriate models for reliability measurement

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR637
Course Title	:	**Tolerance Technology**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To Learn the overall view of Geometric Dimensioning and Tolerancing
CLO2	To Learn the Principles of tolerancing and geometrical tolerancing
CLO3	To Learn the Profile tolerancing and Tolerancing of flexible parts
CLO4	To Learn the suitable geometrical tolerancing method related to components function, manufacturing and inspection

Course Content

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

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

Properties of the surface, Principles for tolerancing and geometrical tolerancing-Symbols- Definitions of geometrical tolerances-Tolerance zone-Form of the tolerance zone- Location and orientation of the tolerance zone-Width of the tolerance zone-Length of the tolerance zone- Common tolerance zone- Datums- Axes and median faces- Screw threads, gears and splines - Angularity tolerances and angular dimension tolerances-Twist tolerance.

Profile tolerancing, Tolerancing of cones, Positional tolerancing, projected tolerance zone, Substitute elements, Maximum material requirement, Envelope requirement, least material requirement

Tolerancing of flexible parts, Tolerance chains (accumulation of tolerances), Statistical tolerancing, respecting geometrical tolerances during manufacturing-Manufacturing Influences-Recommendations for manufacturing

General geometrical tolerances, Tolerancing principles, Inspection of geometrical deviations, Function, manufacturing, and inspection related geometrical tolerancing, Examples of geometrical tolerancing, Tolerancing of edges, ISO Geometrical Product Specifications (GPS).

References

1.	Gene R. Cogorno “Geometric Dimensioning and Tolerancing for Mechanical Design”, McGraw-Hill,2006
2.	Georg Henzold “Geometrical Dimensioning and Tolerancing for Design,

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

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Identify the general dimensioning techniques
CO2	Apply the principles of tolerance in Manufacturing
CO3	Calculate the optimum material requirement
CO4	Identify the suitable geometrical tolerancing methods related to components function, manufacturing and inspection

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR638
Course Title	:	**Modeling, Simulation and Analysis**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Building of Models with logic
CLO2	Develop routines to capture uncertainty in systems
CLO3	Modelling and Simulation of Discrete Event Systems

Course Content

Introduction to systems and modelling Discrete and continuous system - Monte Carlo Simulation. Simulation of Single Server Queuing System Simulation of a manufacturing shop Simulation of Inventory System

Random number generation, properties - Generation of Pseudo Random Numbers Tests for Random Numbers

Random variates-Inverse Transform Technique –Direct Transform Techniques Convolution Method Acceptance Rejection – Routines for Random Variate Generation Testing -Analysis of simulation data-Input modelling Verification and validation of simulation models – output analysis for a single model.

Simulation languages and packages Case studies in WITNESS; FLEXSIM, ARENA, SIMQUICK Simulation based optimization-Modelling and Simulation with Petrinets Case studies in manufacturing systems

References

1.	Jerry Banks & John S.Carson, Barry L Nelson, “Discrete event system simulation” ,Prentice Hall
2.	Law A.M, “Simulation Modelling and Analysis”, Tata Mc Graw Hill
3.	NarsinghDeo, “System Simulation with Digital Computer”, Prentice H
4.	Geoffrey Jordon, “System Simulation”, Prentice hall India Ltd

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Develop manufacturing models of discrete event systems
CO2	A generation of uncertainty using random numbers and random variates
CO3	Perform input, output analysis: Verification and validation of models and optimization

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR639
Course Title	:	**Supply Chain Management**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To demonstrate operational purchasing methods and techniques on supplier management and supply in specific business contexts
CLO2	To explain the strategic importance of logistic elements and describe how they affect supply chain management
CLO3	To analyze the creation of new value in the supply chain for customers, society and the environment

Course Content

Introduction to supply chain management -Supply Chain Performance: Achieving Strategic Fit and Scope -Supply Chain Drivers and Metrics.

Planning in Supply chain -Demand Forecasting in a Supply Chain -Aggregate Planning in a Supply Chain – Planning and Managing Inventories in a supply chain.

Designing the Supply chain network –Distribution networks –Transportation networks –Network Design in Supply chain, Network Design in an Uncertain Environment -supply chain optimization.

Managing cross-functional drivers in supply chain -Sourcing Decisions in a Supply Chain -Pricing and Revenue Management in Supply Chain-Information Technology in Supply Chain -Coordination in Supply Chain.

Modern Supply chain management -Reverse supply chain strategies –Green and sustainable practices of Supply chain –Supply chain cases.

References

1.	Sunil Chopra And Peter Meindl, “Supply Chain Management, strategy, planning, and operation”6/e –PHI, second edition, 2014
2.	V.V.Sople, “Supply Chain Management, text and cases”, Pearson Education South Asia, 2012
3.	Janat Shah, “Supply Chain Management, text and cases”, Pearson Education SouthAsia, 2009
4.	Balkan Cetinkaya, Richard Cuthbertson, Graham Ewer,“Sustainable Supply Chain Management: Practical ideas for moving towards best practice”, Springer, 2011
5.	Jeremy F.Shapiro, Thomson Duxbury, “Modeling the Supply Chain”, 2002

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Explain the major building blocks, major functions, major business processes, performance metrics, and major decisions in supply chain networks
CO2	Summarize the foundation for design and analysis of supply chains and synthesize advanced and specialized concepts, principles and models for operational and strategic improvement
CO3	Analytically examine the supply chain of organizations and measure performance improvement

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR640
Course Title	:	**Automation and Control**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	The course is intended to provide knowledge of any industrial operations involving control of position, velocity, temperature, pressure etc
CLO2	It is desirable that most engineers and scientists are familiar with theory and practice of automatic control
CLO3	It will enhance problem-solving skills by applying control theory to design and implement automated systems

Course Content

Introduction: Review of Laplace Transform, Close-loop control versus open-loop control, Linear Time Invariant (LTI) systems.

Representation of physical system: Transfer function and impulse response function, modelling in state space, transformation of mathematical models with MATLAB, signal flow graphs, linearization of nonlinear mathematical models

Mathematical modeling of control systems: Mechanical, Electrical and Electronic systems, liquid-level systems, pneumatic and hydraulic systems.

Time response analysis: Transient and Steady-State Response Analyses, 1st order, 2nd order and higher-order systems, Routh's Stability Criterion, Effects of Integral and Derivative Control Actions on System Performance, SteadyState Errors in Unity-Feedback Control Systems.

Control Systems Analysis and Design by the Root-Locus Method: Plotting Root Loci with MATLAB, Root-Locus Plots of Positive Feedback Systems, Lag, Lead and Lag–Lead Compensation.

Frequency-Response Method: Bode Diagrams, Polar Plots, Log-Magnitude-versus-Phase Plots, Nyquist Stability Criterion.

PID Controllers: Ziegler–Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach. Case study by using MATLAB

References

1.	Modern Control Engineering by K. Ogata, 5th edition, Prentice Hall, 2010
2.	Automatic Control Engineering by F.H. Raven, 5th ed., McGraw Hill International, 1994

3.	Digital Control Systems by B.C. Kuo, Prentice Hall

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Describe the open-loop and closed-loop control system used in practice
CO2	Compare the performance of different control systems by using both the time response and the frequency response method
CO3	Develop practical skills in designing, simulating, and implementing control systems using modern software tools

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3

Course Code	:	PR641
Course Title	:	**Data Science for Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To introduce the fundamental concepts of data science, with a focus on its relevance and application in manufacturing engineering.
CLO2	To equip students with the necessary programming and statistical skills required for data science for manufacturing engineers.
CLO3	To equip students with the skills to apply machine learning algorithms effectively in optimizing and improving manufacturing processes.

Course Content

Introduction to Data Science — Relevance to Manufacturing Engineering — Overview of Big Data in Manufacturing — Introduction to Python — Key Python Libraries for Data Science.

Data Types — Data Collection Methods in Manufacturing — Data Pre-processing — Data Cleaning and Transformation — Handling Missing Values and Outliers — Exploratory Data Analysis (EDA) — Univariate, Bivariate, and Multivariate Analysis — Data Visualization and Analysis Techniques for Manufacturing Insights — Statistics for Data Science — Descriptive Statistics — Inferential Statistics — Hypothesis Testing — Z-test — t-test — Chi-squared Test — ANOVA.

Machine Learning Techniques — Supervised Learning — Linear Regression: Simple, Multiple, Polynomial — Regularizations — Logistic Regression — Multiclass Problems — Tree-Based Models: Decision Trees, Random Forest — Unsupervised Learning — k-Means Clustering — Principal Component Analysis (PCA) — t-SNE.

Artificial Neural Networks (ANN) — Physics-Informed Neural Networks (PINNs) — Applications of Machine Learning in Manufacturing — Industry 4.0 — Case Studies of AI-Driven Improvements in Manufacturing Efficiency and Quality.

References

1.	Ross, Sheldon, Introduction to Probability and Statistics for Scientists and Engineers, Elsevier, 2014
2.	Shah, Chirag, A Hands-On Introduction to Data Science, Cambridge University Press, 2020.
3.	James, G., Witten, D., Hastie, T., & Tibshirani, R. “An Introduction to Statistical Learning,” New York, Springer, 2013.
4.	Montgomery, Douglas C., Elizabeth A. Peck, and G. Geoffrey Vining.

	Introduction to linear regression analysis. John Wiley & Sons, 2021.
5.	Kane, Frank. Hands-on data science and python machine learning. Packt Publishing Ltd, 2017.

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Demonstrate the relevance and application of data science in solving manufacturing engineering problems.
CO2	Develop proficiency in Python and statistical methods, enabling the students to analyze and interpret data in the context of manufacturing.
CO3	Apply machine learning algorithms to real-world manufacturing processes, optimizing efficiency and improving quality through data-driven decision-making.

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	1	2	3
CO2	2	2	3
CO3	3	2	3

Course Code	:	PR642
Course Title	:	**Condition Monitoring of Machine**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To prevent catastrophic failure of machines used in industry.
CLO2	To provide the knowledge of different techniques of fault diagnosis used for machinery fault diagnosis.
CLO3	To learn vibration-based technique to diagnose the faults in the machines.

Course Content

Introduction to condition-based monitoring, fault diagnosis and prognosis, machine learning in fault diagnosis.
Condition monitoring techniques: vibration and noise monitoring, wear debris and oil analysis, thermography, performance analysis, noise monitoring, temperature monitoring, wear behaviour monitoring. acoustic emission, ultrasonics, Eddy current.

Vibration Analysis: basics of vibration, free and forced response, vibration control, random vibration, statistical parameters i.e. RMS value, peak value, crest factor, kurtosis, standard deviation of vibration signals.

Instrumentation: data recording, data acquisition, errors in measurements, transducers, accelerometer, sound level meter, Proximity probes, velocity transducers, laser vibrometers, dual vibration probes, shaft encoders.

Signal processing: sample rate and aliasing, filtering, time domain signal analysis, frequency domain signal analysis, non-stationery signal analysis, Fourier series, Fast Fourier Transform, wavelet transform, Hilbert transform, modulation and sidebands, orbit and order analysis, cepstrum analysis

Faults in rotating machines: unbalance, misalignment, crack, spalling, loosening, fault in electrical machines.
Failure analysis of rotating machines, bearings and gears, fans, blowers, pumps, IC Engines.

References

1.	Machinery Condition Monitoring: Principles and Practices, Mohanty A.R., CRC Press, 2014
2.	Vibration Condition Monitoring, Rao J. S., Narosa Publishing House, 2000
3.	Hand book of Condition Monitoring, Allan Davis, Chapman and Hall, 2000
4.	Instrumentation, Measurement and Analysis, Choudary K K., Tata McGraw Hill,

	2012
5.	Vibration Based Condition Monitoring, Randall R. B., Wiley

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Understand the condition-based monitoring used in industries
CO2	Apply condition monitoring techniques.
CO3	Analyze the signals in time and frequency domains.
CO4	Diagnose the faults in machines.

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3

Course Code	:	PR643
Course Title	:	**Human Machine Interaction for Manufacturing**
Type of Course	:	PE
Prerequisites	:	
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand and apply cognitive psychology and ergonomics principles in the design and evaluation of human-machine interactions to improve usability and performance in manufacturing environments.
CLO2	To equip students with practical skills in usability evaluation methods, including statistical hypothesis testing.
CLO3	To explore the applications of AR/VR and haptics technologies in enhancing manufacturing processes.

Course Content

Cognitive Psychology in Manufacturing - Basic principles of Visual and Auditory perception - Memory Structure - Classification and retrieval of errors - Rapid Aiming Movement - Fitts' Law - Implication in interaction design - User Modelling.

Introduction to Ergonomics - Anthropometry and Biomechanics - Sensory Capability and Display Design - Manual and VR Interactions - Human Error Causes and Mitigation.

Ergonomic Principles - Usability Evaluation – Heuristics evaluation - User Trial Design - Statistical Hypothesis Testing - t- test – ANOVA - AR/VR/Haptics Technologies in Manufacturing - History of AR/VR

References

1.	Shneiderman B. "Designing the User Interface - Strategies for Effective Human-Computer Interaction." Pearson Education
2.	Buxton B., Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kaufmann Publishers
3.	Field A. Discovering Statistics Using SPSS, SAGE Publications Ltd., 2009
4.	The Wiley Handbook of Human Computer Interaction Set, John Wiley & Sons

Course Outcomes (CO)

At the end of the course student will be able to

CO1	Analyze and apply cognitive psychology principles and ergonomic design principles to enhance human-machine interactions and improve system usability in manufacturing settings.
CO2	Evaluate and implement usability testing methods, including statistical hypothesis testing, to assess and refine interfaces and systems to solve manufacturing challenges.
CO3	Comprehend the effectiveness of Augmented Reality (AR), Virtual Reality (VR), and haptics technologies in enhancing manufacturing processes

Mapping of Programme Outcomes with Course Outcomes:

CO / PO	PO1	PO2	PO3
CO1	2	2	2
CO2	2	2	3
CO3	2	2	2