NOORUL ISLAM CENTRE FOR HIGHER EDUCATION

(Deemed to be University Under Section 3 of the UGC Act, 1956)
Kumaracoil, Thuckalay

DEPARTMENT OF MECHANICAL ENGINEERING

M.E. Computer Integrated Manufacturing

CURRICULUM AND SYLLABI

REGULATION 2023

NOORUL ISLAM CENTRE FOR HIGHER EDUCATION, Kumaracoil

Regulation : 2023

Curriculum and Syllabi

DEPARTMENT OF MECHANICAL ENGINEERING

M.E COMPUTER INTEGRATED MANUFACTURING

Vision of the University

To be recognized by the Government and society at large as an institution able to deliver excellence with relevance in the field of higher education and research focusing on the needs of the nation in tune with the technological revolution to cope with the knowledge explosion and global competence.

Mission of the University

To develop the institution as a Centre of Excellence, keeping pace with the advances in the field, so as to provide quality higher education to the students and instill in them high standards of discipline and ethics so that they become enlightened individuals in the service of humanity and to carry out focused research in the frontier areas of science and technology.

Faculty of Mechanical Engineering

Department of Mechanical Engineering

Vision of the Department

To become a centre of excellence in teaching, research & development by producing innovative and creative mechanical engineers to meet the global challenges.

Mission of the Department

To achieve National and International recognition by providing educational needs & Industry requirements through unique programs in Mechanical Engineering.

Description of the programme

Computer-integrated manufacturing (CIM) refers to the use of computer-controlled machineries and automation systems in manufacturing products. CIM combines various technologies like computer-aided design (CAD) and computer-aided manufacturing (CAM) to provide an error-free manufacturing process that reduces manual labor and automates repetitive tasks. The CIM approach increases the speed of the manufacturing process and uses real-time sensors and closed-loop control processes to automate the manufacturing process. It is widely used in the automotive, aviation, space and ship-building industries.

Programme Educational Objectives - PEO	
PEO-01	To train students with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real life problems
PEO-02	To Impart knowledge to students in recent advances in the Computer Integrated Manufacturing Engineering to educate them to prosper in Manufacturing engineering and research related professions.
PEO-03	To inculcate students with professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate Computer Integrated Manufacturing engineering issues to broader engineering and social context.
PEO-04	To inculcate students in professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate Manufacturing engineering issues to broader social context.
PEO-05	To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career

Graduate Attributes-GA	
GA-1	**Advanced Engineering Expertise** Master advanced engineering principles and apply them to design, analyze, and innovate systems that address both present and emerging global challenges across diverse industries.
GA-2	**Leadership in Research and Innovation** Lead groundbreaking research and foster innovation by identifying opportunities for technological advancements, contributing original ideas that push the boundaries of engineering knowledge.

GA-3	**Sustainable Engineering Practices** Develop and implement engineering solutions that integrate sustainability, environmental stewardship, and resource efficiency, ensuring the long-term impact and responsibility of all projects.
GA-4	**Ethical and Strategic Decision-Making** Make informed, ethical decisions in complex engineering contexts, considering societal needs, environmental implications, and the long-term consequences of engineering practices.
GA-5	**Global Competence in Engineering Solutions** Exhibit a deep understanding of global engineering standards and practices, addressing international challenges and cultural sensitivities in engineering projects to make a broader societal impact.
GA-6	**Technological Agility and Lifelong Learning** Stay ahead of technological trends and exhibit agility in learning new tools, methodologies, and technologies, ensuring continuous professional growth in a rapidly evolving engineering landscape.
GA-7	**Interdisciplinary and Collaborative Innovation** Excel in multidisciplinary collaborations, leveraging knowledge from multiple fields to solve complex, large-scale engineering problems that require comprehensive and innovative solutions.
GA-8	**Data-Driven Decision Making** Employ advanced data analytics, machine learning, and computational tools to derive insights and make informed engineering decisions that improve performance, efficiency, and sustainability.
GA-9	**Entrepreneurial Mindset and Innovation Leadership** Cultivate an entrepreneurial mindset, translating engineering innovations into viable products, solutions, or services, and leading teams toward commercialization and societal impact.
GA-10	**Safety, Risk, and Crisis Management** Implement and manage advanced safety protocols and risk mitigation strategies to protect individuals, communities, and ecosystems in engineering practices, particularly in high-stakes and crisis environments.

Programme Outcome - PO	
PO-A	To impart the concepts of Computer Aided Design and Computer Aided Manufacturing engineering through the use of analytical techniques, experiments, computer simulation methods and other modern engineering tools.
PO-B	Able to take up profession in R&D areas, management and teaching activity in the field of mechanical engineering.
PO-C	Engage in industry institute interaction and lifelong learning by adhering to ethical and environmental conditions.

P0-D	Apply the technical skills gained to model and analyze real time projects in the field of Computer Integrated Manufacturing.
PO-E	Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.
PO-F	Graduates will demonstrate knowledge of professional and ethical responsibilities.
PO-G	Graduates will be able to communicate effectively in both verbal and written form.
PO-H	Graduates will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.
PO-I	Graduates will develop confidence for self-education and ability for lifelong learning.

Mapping of Graduate Attributes and Programme Educational Objectives(PEO)

GAs / PEOs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10
PEO-01	**H**	**H**	**A**	**H**	**H**	**A**	**A**	**A**	**A**	**H**
PEO-02	**H**	**H**	**H**	**A**	**H**	**A**	**A**	**H**	**A**	**A**
PEO-03	**A**	**H**	**A**	**A**	**H**	**H**	**H**	**H**	**A**	**A**
PE0-04	**H**	**H**	**A**	**H**	**H**	**A**	**A**	**A**	**H**	**H**
PEO-05	**A**	**A**	**H**	**A**	**H**	**H**	**H**	**H**	**A**	**H**

H- Highly Associated A- Associated Not – Not Associated

Mapping of Graduate Attributes and Programme Outcomes (PO)

GAs / POs	GA-01	GA-02	GA-03	GA-04	GA-05	GA-06	GA-07	GA-08	GA-09	GA-10
PO-A	**H**	**A**	**H**	**A**	**A**	**H**	**A**	**H**	**A**	**H**
PO-B	**A**	**H**	**H**	**A**	**H**	**A**	**H**	**A**	**A**	**A**
PO-C	**H**	**A**	**H**	**A**	**A**	**A**	**H**	**H**	**A**	**A**
P0-D	**A**	**H**	**A**	**H**	**H**	**A**	**A**	**A**	**A**	**H**
PO-E	**A**	**A**	**A**	**A**	**A**	**H**	**H**	**H**	**A**	**H**
PO-F	**H**	**H**	**A**	**A**	**H**	**A**	**A**	**H**	**H**	**A**
PO-G	**A**	**A**	**H**	**A**	**A**	**H**	**A**	**A**	**A**	**H**
PO-H	**H**	**A**	**H**	**H**	**A**	**A**	**H**	**A**	**A**	**A**
PO-I	**A**	**H**	**A**	**H**	**H**	**A**	**A**	**H**	**A**	**A**

H- Highly Associated A- Associated Not – Not Associated

Mapping of Programme Educational Objective (PEOs) and Programme Outcomes (POs)

PEO / PO	PEO-01	PEO-02	PEO-03	PEO-04	PEO-05	PEO-06	PEO-07	PEO-08
PO-A	**H**	**H**	**A**	**A**	**H**	**H**	**H**	**A**
PO-B	**H**	**A**	**H**	**H**	**A**	**A**	**A**	**A**
PO-C	**A**	**H**	**A**	**H**	**A**	**A**	**H**	**A**
P0-D	**H**	**H**	**A**	**A**	**A**	**A**	**H**	**A**

PO-E	**H**	**H**	**H**	**H**	**H**	**A**	**H**	**H**
PO-F	**H**	**A**	**A**	**A**	**H**	**H**	**A**	**A**
PO-G	**H**	**A**	**A**	**H**	**H**	**H**	**A**	**A**
PO-H	**A**	**H**	**H**	**A**	**A**	**A**	**H**	**H**
PO-I	**H**	**A**	**H**	**A**	**A**	**H**	**A**	**H**

H- Highly Associated A- Associated Not – Not Associated

Duration of the programme: 2 Years/ 4 Semesters

Total credit: 69

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CM4501	Optimization Technique	3	1	0	4
2.	CM4502	Computer Integrated Manufacturing	3	0	0	3
3.	CM4503	CAD/CAM	3	0	0	3
4.	CM45XX	Elective I (Core)	3	0	0	3
5.	CM45XX	Elective II (Core)	3	0	0	3
6.	OE45D1	Research Methodology & IPR	2	0	0	2
PRACTICAL						
7.	CM4571	CAD/CAM Laboratory	0	0	4	2
Total			**17**	**1**	**4**	**20**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CM4504	Computerized Metrology	3	1	0	4
2.	CM4505	Manufacturing planning and control optimization	3	0	0	3
3.	CM4506	Competitive Manufacturing Systems	3	0	0	3
4.	CM4507	Mechatronics in Manufacturing Systems	3	0	0	3
5.	CM45XX	Elective IV (Core)	3	0	0	3
6	CM45XX	Elective V (Core)	3	0	0	3
PRACTICAL						
7.	CM4572	Advanced Metrology Lab	0	0	4	2
Total			**18**	**1**	**4**	**21**

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CM4508	Design for Manufacturing and assembly Systems	3	0	0	3
2.	CM45XX	Elective VI (Open Elective)	3	0	0	3
PRACTICAL						
3.	CM45P1	Preliminary work on Dissertation	0	0	18	6
Total			**6**	**0**	**18**	**12**

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	CM45P5	Dissertation	0	0	32	16
Total			**0**	**0**	**32**	**16**

CORE ELECTIVES

Sl.No	COURSE CODE	COURSE NAME	L	T	P	C
1.	CM45A1	Computer Aided Process Planning	3	0	0	3
2.	CM45A2	Design for Manufacturing	3	0	0	3
3.	CM45A3	Design of Cellular Manufacturing System	3	0	0	3
4.	CM45A4	Finite Element Analysis in Manufacturing Engineering	3	0	0	3
5.	CM45A5	Advances in Welding and Casting Technology	3	0	0	3
6.	CM45A6	Precision Engineering	3	0	0	3
7.	CM45A7	Manufacturing Management	3	0	0	3
8.	CM45A8	Applied Materials Engineering	3	0	0	3

9.	CM45A9	Micro and Nano Manufacturing	3	0	0	3
10.	CM45B1	Lean Manufacturing and Six Sigma	3	0	0	3
11.	CM45B2	Machine Learning	3	0	0	3
12.	CM45B3	Computer Applications in Design	3	0	0	3
13.	CM45B4	Research Methodology and IPR	3	0	0	3
14.	CM45B5	Industrial Robotics and expert systems	3	0	0	3
15.	CM45B6	Additive Manufacturing	3	0	0	3
16.	CM45B7	MEMS and Nanotechnology	3	0	0	3
17.	CM45B8	Polymers and Composite Materials	3	0	0	3
18.	CM45B9	Material Characterization Techniques	3	0	0	3
19.	CM45C1	Manufacturing System Simulation	3	0	0	3
20.	CM45C2	Data Analytics	3	0	0	3
21.	CM45C3	Internet of Things for Manufacturing	3	0	0	3
22.	CM45C4	Warehouse Layout Planning and Part Feeding Methods	3	0	0	3
23.	CM45C5	Total Quality Systems and Engineering	3	0	0	3
24.	CM45C6	Tool Engineering	3	0	0	3
25.	CM45C7	Green Manufacturing	3	0	0	3
26.	CM45C8	Sensors for Manufacturing and Condition Monitoring	3	0	0	3
27.	CM45C9	Reliability and Total Productive Maintenance	3	0	0	3
28.	CM45D1	Project Management	3	0	0	3
29.	CM45D2	Advanced Machine Tool Design	3	0	0	3
30.	CM45D3	Management of Manufacturing Systems	3	0	0	3
31.	CM45D4	Design of Fluid Power Systems	3	0	0	3
32.	CM45D5	Electronics Manufacturing Technology	3	0	0	3
33.	CM45D6	Environment Conscious Manufacturing	3	0	0	3
34.	CM45D7	Evolutionary Computation	3	0	0	3
35.	CM45D8	Sustainable Manufacturing	3	0	0	3

36.	CM45D9	Intelligent Product Design and Manufacturing	3	0	0	3
37.	CM45E1	Intelligent Manufacturing Systems	3	0	0	3
38.	CM45E2	Enterprise Resource Planning	3	0	0	3
39.	CM45E3	Micro Electro Mechanical Systems	3	0	0	3
40.	CM45E4	Product Lifecycle Management	3	0	0	3
41.	CM45E5	Industry 4.0	3	0	0	3

OPEN ELECTIVE

Sl.No.	**SUBJECT CODE**	**SUBJECT NAME**	**L**	**T**	**P**	**C**
1.	OE45D1	Research Methodology and IPR	2	0	0	2
2.	OE45D2	Business Analytics	3	0	0	3
3.	OE45D3	Industrial Safety	3	0	0	3
4.	OE45D4	Operations Research	3	0	0	3
5.	OE45D5	Composite Materials	3	0	0	3
6.	OE45D6	Waste to Energy	3	0	0	3

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CM4501	Optimization Technique	3	1	0	4
2.	CM4502	Computer Integrated Manufacturing	3	0	0	3
3.	CM4503	CAD/CAM	3	0	0	3
4.	CM45XX	Elective I (Core)	3	0	0	3
5.	CM45XX	Elective II (Core)	3	0	0	3
6.	OE45D1	Research Methodology & IPR	2	0	0	2
PRACTICAL						
7.	CM4571	CAD/CAM Laboratory	0	0	4	2
Total			**17**	**1**	**4**	**20**

CM4501	OPTIMIZATION TECHNIQUE	L	T	P	C
		3	**1**	**0**	**4**

OBJECTIVES:

- Learn to solve integer programming problems
- To know how to solve the Dynamic programming problems
- Learn to solve nonlinear programming problems with unconstrained optimization problems
- Understand to solve non-linear programming problems using KKT conditions, quadratic and separable programming
- To create awareness of Metaheuristic algorithms.

Course Outcome – Cos		Cognitive Skill
CO-01	Know how to solve integer programming problems	U
CO-02	Able to solve Dynamic programming problems	A,R
CO-03	Familiar in solving unconstrained non-linear optimization problems	U
CO-04	Familiar in solving constrained liner optimization problems	A
CO-05	Know how to solve non-linear optimization problems using Metaheuristic algorithms	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTEGER PROGRAMMING **12**

Branch and Bound technique – cutting plane algorithm method - Travelling Salesman problem - Traveling Salesman Problem-Branch and Bound Algorithms for TSP-Heuristics for TSP-Chinese Postman Problem-Vehicle Routeing Problem

UNIT II: DYNAMIC PROGRAMMING **12**

Characteristics of Dynamic Programming Problems - Deterministic Dynamic Programming - Forward and Backward recursive recursion– selected dynamic programming application– investment model– inventory model– replacement model–reliability model–stage coach problem.

UNIT III: NONLINEAR PROGRAMMING-I **12**

Types of Nonlinear Programming Problems-One-Variable Unconstrained Optimization Multivariable Unconstrained Optimization

UNIT IV: NONLINEAR PROGRAMMING–II **12**

The Karush-Kuhn-Tucker (KKT) Conditions for Constrained Optimization Quadratic Programming- Separable Programming-Convex Programming-Nonconvex Programming.

UNIT V: NON-TRADITIONAL OPTIMIZATION **12**

Overview of Genetic algorithms, Simulated, Annealing, neural network-based optimization. Particle Swarm optimization, Ant Colony Optimization, Optimization of Fuzzy Systems.

TOTAL:60 PERIODS

REFERENCES:

1. Fredrick S.Hillierand G.J.Liberman, "Introduction to Operations Research", McGraw Hill Inc.1995.
2. Kalymanoy Deb,"OptimizationforEngineeringDesign",PHI,2021
3. Christos H.Papadimitriou,KennethSteiglitz,CombinatorialOptimization,PHI2020.
4. Ravindran–Phillips–Solberg, "Operations Research–Principles and Practice", John Wiley India,2006.
5. Singiresu.S.Rao,"Engineeringoptimization–Theoryandpractices",JohnWileyand Sons,1996.

CM4502	COMPUTER INTEGRATED MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To familiarize the student with current trend in production management activities.
- To impress and prepare them to use modern technologies in future management systems.
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Course Outcome – Cos		Cognitive Skill
CO-01	To manage efficiently various activities of production with the help of technology	U
CO-02	Expected to use modern technologies in future management systems	A
CO-03	To know the management of inventory	A
CO-04	Improve knowledge on shop floor control	S
CO-05	To manage the use of computer in controlling and monitoring	RA

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I PRODUCTION PLANNING AND CONTROL AND FORECASTING: 9

Introduction: Production Planning and Control-Traditional Production Planning and Control - Problems with Traditional Production Planning and Control-Computer-Integrated Production Management System Engineering and manufacturing data base –Forecasting - Qualitative methods: Delphi technique, Market research, Intrinsic methods-Time series-moving averages-exponential smoothing-Extrinsic methods regression-forecast errors-numerical problems

UNIT II AGGREGATE PLANNING: 8

Planning hierarchy-Aggregate production planning (APP)-need-Alternatives for managing supply and demand-basic strategies-numerical problems-APP methods-Master Production Scheduling.

UNIT III RESOURCE PLANNING 10

Inventory Management - Inventory types and general control procedures-Order point systems-The inventory management module- -Material Requirements Planning- Basic MRP Concepts-capacity requirements planning-Distribution requirements planning-Independent versus dependent demand Lumpy demand-Lead times-Common use items-Inputs to MRP-numerical problems-Manufacturing Resource planning-Enterprise planning.

UNIT IV SHOP FLOOR CONTROL: 9

Shop Floor Control -Functions of Shop Floor Control-Priority control and assignment of shop orders Maintain information on work-in-process-Monitor shop order status-Production output data for capacity control-The Shop Floor Control System -Order release-Order scheduling-Order progress-Operation Scheduling-An overview of the scheduling problem-Priority rules for job sequencing-The Factory Data Collection System-Job traveler-Employee time sheet-Operation tear strips-Centralized shop terminal Individual work center terminals-Voice data input

UNIT V COMPUTER PROCESS MONITORING AND CONTROL 9

Computer Process Monitoring: Data logging systems-Data acquisition systems-Multilevel scanning Computer Control: Computer-Process Interfacing-Manufacturing Process Data-System Interpretation of Process Data-Interface Hardware Devices-Digital Input/Output Processing Interrupt system -Control Programming-Computer Process Control-Structural Model of a

Manufacturing Process-Process Control Strategies-Distributed Control versus Central Control-Supervisory Computer Control.

TOTAL: 45 PERIODS

REFERENCES:

1. Bauer, A., Browne, J., Bowden, R., and Duggan, J. “Shop Floor Control Systems From design to implementation”, springer,1994.
2. ChryssolourisG.,"ManufacturingSystems:Theory and Practice", Second Edition 2020, Springer.
3. Groover, M.P. and Zimmers, JR E.R.,”CAD/CAM: Computer-Aided Design and Manufacturing”, Prentice Hall 1983.
4. Mahadevan "Operations Management: Theory and practice",3rd edition, Pearson,2020.
5. Mahapatra, P.B.,” Computer-Aided Production Management”, Prentice-Hall of India Pvt. Limited, 2004.
6. Singh, N., “Systems Approach to Computer Integrated Design and Manufacturing”, John Wiley & Sons, edition 7th 2021.

CM4503	CAD/CAM	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the evolution of CAD, CAM, CIM, engineering product specification and interpreting geometric specifications.
- To train the candidates on the integration of Computer Aided Design and Computer Aided Manufacturing.
- To impart knowledge on manual part program and generation of CNC part program using Computer Aided Manufacturing packages.
- To introduce with the implementation of CAD and CAM in manufacturing process.
- To introduce the importance of Internet of Things in Computer Aided Manufacturing.

Course Outcome – Cos		Cognitive Skill
CO-01	Recognize the importance of CAD, CAM, CIM, Engineering product specification and interpreting geometric specifications.	R
CO-02	Improve knowledge on the integration of CAD and CAM	U
CO-03	Exhibit competency in manual part program and generation of CNC part program using CAM packages	S
CO-04	Describe the implementation of CAD and CAM in manufacturing processes.	A
CO-05	Explain applications of IOT in computer aided manufacturing.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	L	M	L	S	M
CO-02	S	M	L	L	L	M	L	M	S
CO-03	S	S	M	M	L	L	L	L	M
CO-04	M	S	M	L	S	M	L	M	S
CO-05	S	S	M	M	L	L	L	L	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO CAM **9**

Introduction CAD, CAM, CAE, CIM, system configuration for CAM including hardware and software, evolution of product realization, historical development, engineering product specification. Geometric Tolerancing - ASME standard, interpreting geometric specifications, multiple part features and datum.

UNIT II: CAD AND CAM INTEGRATION **9**

Introduction - Networking - Techniques, components, interface cards, network standards, Graphics standards - Graphical kernel system, Data exchange format - IGES and STEP. Process planning, Computer Aided Process Planning (CAPP), Product life cycle management (PLM), Enterprise resource planning (ERP).

UNIT III: PROGRAMMING OF CNC MACHINES **9**

Structure of CNC program, Coordinate system, G & M codes, cutter radius compensation, tool nose radius compensation, tool wear compensation, canned cycles, mirroring features, Manual part programming for CNC turning, machining center, wire electric discharge machining, abrasive water jet cutting machine, bulk and sheet metal forming, generation of CNC program using CAM softwares.

UNIT IV: CAD AND CAM FOR MANUFACTURING PROCESSES **9**

Classification of Manufacturing process, construction and operations, Integration of CAD and CAM in CNC turning center, machining center, electric discharge machining, wire electric discharge machining, abrasive water jet cutting machine, bulk forming, sheet metal forming.

UNIT V: IOT IN CAM **9**

Introduction, overview of IOT enabled manufacturing system, Real-time and multi-source manufacturing information sensing system, IOT enabled smart assembly station, cloud computing-based manufacturing resources configuration method, Real-time key production performances analysis method, Real-time information driven production scheduling system.

TOTAL: 45 PERIODS

REFERENCES:

1. Chang T.C., Wysk, R.A. and Wang.H.P., “Computer Aided Manufacturing”, Pearson Prentice Hall, India ,2009, ISBN: 978-0131429192.
2. HMT,“Mechatronics”, Tata McGraw-Hill Publishing Company Limited, New Delhi, edition 6, 2021.
3. Rao P.N., “CAD/CAM”, 6th Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, India, 2021,
4. Radhakrishnan P., “Computer Numerical Control ", New Central Book Agency, India,2013.
5. Nee Y.C., Soh K. Ong, Yun G. Wang., “Computer Applications in Near Net-Shape Operations”, Springer, United Kingdom, 2012.
6. Yingfeng Zhang and Fei Tao, “Optimization of Manufacturing Systems Using the Internet of Things” Academic Press, United Kingdom, 2020.

CM4571	CAD/CAM LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To familiarize the students with CAD and CAE modules.
- To create basic sketches and to design part modelling for the given mechanical components.
- To generate assemblies from the part model with respect to the constraints and to various data exchange formats.
- To familiarize the students with reverse engineering as a tool to create 3D models for 3D printing.
- To gain practical knowledge in CAE module through Finite Element Analysis.

Course Outcome – Cos		Cognitive Skill
CO-01	Apply knowledge on CAD and CAE modules	A
CO-02	Build and design interactive CAD models.	U,A
CO-03	Interpret the given mechanical components and to design for 3D printing.	E
CO-04	Demonstrate the use of FEA package.	S
CO-05	Make use of assemble parts, evaluate the information and resources using FEA.	R,E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

LIST OF EXPERIMENTS:

1. Sketching and Part modelling (Solid modelling, Surface modelling, Feature manipulation) of mechanical components using CAD software package.
2. Assembly (Constraints, Exploded Views, Interference check) and Drafting (Layouts, Geometric Dimensions &Tolerance Standards, Sectional Views, & Detailing) of mechanical components using CAD software package.
3. Working with CAD Data Exchange formats: IGES, PDES, PARASOLID, DXF and STL
4. Study and exercise on freeform modelling.
5. Reverse engineering the given product/component and convert the data into 3D model.
6. Exercise on. STL file Preparation, Slicing, Support Structure Generation & Build setup Preparation.
7. CNC code generation for CNC Milling.
8. CNC code generation for CNC Turning.
9. Demonstration of CNC Router Machine/ CNC Lathe/ CNC Milling (Students have to submit detailed reports on each demonstrations).

TOTAL: 60 PERIODS

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CM4504	Computerized Metrology	3	1	0	4
2.	CM4505	Manufacturing planning and control optimization	3	0	0	3
3.	CM4506	Competitive Manufacturing Systems	3	0	0	3
4.	CM4507	Mechatronics in Manufacturing Systems	3	0	0	3
5.	CM45XX	Elective IV (Core)	3	0	0	3
6	CM45XX	Elective V (Core)	3	0	0	3
PRACTICAL						
7.	CM4572	Advanced Metrology Lab	0	0	4	2
Total			**18**	**1**	**4**	**21**

CM4504	COMPUTERIZED METROLOGY	L	T	P	C
		3	**1**	**0**	**4**

OBJECTIVES:

- To teach the concepts of metrology.
- To train the students in various aspects of measurement of surface roughness.
- To train the students in the area of interferometry and form measurements.
- To train the students with understanding the fundamental principles of computer aided inspection and laser metrology.
- To introduce the basic principles of image processing and machine vision in context to metrological applications.

Course Outcome – Cos		Cognitive Skill
CO-01	Illustrate the fundamental concepts of measurement, standards, calibration, maintenance of laboratory facilities and handling of metrological equipments.	A
CO-02	Explain the roughness and its applications in manufacturing research, learn the important concepts, principles and applications related to interferometry.	R
CO-03	Justify the use of interferometry related sophisticated measurement and inspection facilities.	S
CO-04	Relate the concepts of Computer aided inspection technologies for industrial Situations, design and develop new inspection techniques.	U,An
CO-05	Discuss the importance of image processing techniques and the possibilities of developing new heuristics for image processing related to metrology.	R,E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: CONCEPTS OF METROLOGY **9**

Introduction – Terminologies – Standards of measurement – Interchangeability – Selective assembly – Accuracy and Precision – Calibration of instruments – Errors in measurements –

Laboratory accreditation, Basics of dimensional metrology and Form metrology – Clean room – Maintenance and handling of metrology equipment's – Standard practices of inspection rooms.

UNIT II: MEASUREMENT OF SURFACE ROUGHNESS 9

Introduction – Types of Surface Texture – Surface Roughness Measurement Methods – Roughness parameters, bearing area parameters, Contact and Non-Contact type roughness measuring instruments, 3D Surface Roughness Measurement – Nano Level Surface Roughness Measurement – Instruments: Scanning Electron Microscope(SEM), Transmission Electron Microscope(TEM), Scanning and Transmission Electron Microscope(STEM), Atomic Force Microscopy(AFM).

UNIT III: INTERFEROMETRY 9

Introduction – Principles of Interferometry – Optical flats in assessing surface contours - Interferometers – Measurement and Calibration – Laser Interferometry – Engineering applications of interferometry.

UNIT IV: COMPUTER AIDED INSPECTION AND LASER METROLOGY 9

Introduction – Computer Aided Inspection Techniques – Tool Makers Microscope – Coordinate Measuring Machines – Applications – Advanced Laser gauging techniques – Lasers in precision Measurements – Laser Scanners for Reverse Engineering – In-process inspection -Industrial case studies.

UNIT V: MACHINE VISION AND IMAGE PROCESSING 9

Introduction – Machine vision – Overview – Computer imaging systems, Image Analysis, Preprocessing, Human Vision System, Image model, Image enhancement, gray scale models, histogram models, Image Transforms – Applications of image processing -Advantages and limitations and Case studies

TOTAL: 45 PERIODS

REFERENCES:

1. "ASTE Handbook of Industries Metrology", Prentice Hall of India Ltd., India,1992.
2. Bewoor A.K. and Kulkarni V.A.,"Metrology and Measurement", Tata McGraw-Hill, India, 2020.
3. Galyer F.W. and Shotbolt C.R., "Metrology for engineers", ELBS, Germany, 1990.
4. Jain R.K., "Engineering Metrology", Khanna Publishers, India, 2008.
5. Smith G.T., "Industrial Metrology", Springer, United States, 2022.

CM4505	MANUFACTURING PLANNING AND CONTROL OPTIMIZATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce students with Current Trends in Manufacturing Planning and Control System and Forecasting activities.
- To impart basic concepts of Aggregate Production Planning.

- To elaborate on Inventory management and Resource Requirements.
- To be familiarized with the functions of Shop Floor Control and associated systems.
- To gain knowledge on Computer Process Monitoring, Computer Process Interfacing and Process Control Strategies.

Course Outcome – Cos		Cognitive Skill
CO-01	Evaluate the various activities of Manufacturing Planning and Control System and Forecasting activities.	E
CO-02	Outline the concepts of Aggregate Production Planning.	R
CO-03	Organize the Inventory management and Resource Requirements.	U
CO-04	Develop the functions of Shop Floor Control and associated systems.	U,S
CO-05	Simplify the computer Process Monitoring, Computer Process Interfacing and Process Control Strategies.	R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: MANUFACTURING PLANNING AND CONTROL AND FORECASTING 9

Introduction: Production Planning and Control-Limitations with Traditional Production Planning and Control-Need and Evolution of Manufacturing Planning and Control (MPC) System -Basic

framework - Demand Management in MPC System- Forecasting: Time Horizon, Design of Forecasting Systems - Developing the Forecast Logic– Qualitative methods: Delphi Technique, Market Research, Quantitative methods -Time Series - Moving Averages, Exponential Smoothing -Regression- Measure of Forecast Accuracy- Numerical Problems

UNIT II: AGGREGATE PRODUCTION PLANNING 9

Introduction-Need for Aggregate production planning (APP) - Alternatives for Managing Demand Reservation of Capacity, Influencing Demand - Alternatives for Managing Supply - Inventory based Capacity Adjustment, Capacity Augmentation, Basic Strategies - Level, Chase, Mixed - Numerical Problems - APP Methods - Heuristic Methods, Optimal Methods.

UNIT III: RESOURCE PLANNING 9

Inventory Management - Inventory Types and Control Procedures - Order point systems - Inventory Management Module - Rough-Cut Capacity Planning- Master Production Schedule - Material Requirements Planning (MRP) - Basic Concepts of MRP -Inputs to MRP- MRP Logic - Capacity Requirements Planning - Distribution Requirements Planning - Manufacturing Resource Planning (MRP II) - Enterprise Resource Planning (ERP)-Case studies.

UNIT IV: SHOP FLOOR CONTROL 9

Shop Floor Control - Functions - Shop Floor Control System - Order Release - Order Scheduling - Order Progress - Operation Scheduling-Priority Rules for Job Sequencing - The Factory Data Collection System - Online and Offline Data Collection Systems - Case studies.

UNIT V: PROCESS MONITORING AND CONTROL 9

Computer Process Monitoring: Data Logging Systems - Data Acquisition Systems - Multilevel Scanning - Computer Control: Computer-Process Interfacing - Manufacturing Process Data - System Interpretation of Process Data - Interface Hardware Devices - Digital Input / Output Processing Interrupt system - Control Programming - Computer Process Control - Structural Model of a Manufacturing Process - Process Control Strategies-Case studies.

TOTAL: 45 PERIODS

REFERENCES

1. Groover M. and Zimmers E., “CAD/CAM: Computer-Aided Design and Manufacturing”, Prentice Hall., India, Reprint 2022, ISBN-13: 978-0131101302.
2. Mahadevan B., "Operations Management: Theory and practice", Pearson., India, 2015.
3. Mahapatra P.B., “Computer-Aided Production Management”, Prentice-Hall, India, 2004.
4. Nanua Singh, "System Approach to Computer Integrated Design and Manufacturing", Wiley India Edition, Reprint 2021.
5. Thomas E. Vollmann, William Lee Berry, David Clay Whybark and Robert Jacobs F., “Manufacturing Planning and Control Systems for Supply Chain Management”, McGraw Hill., United States, 2022.

CM4506	COMPETITIVE MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart the concepts of group technology and flexible manufacturing systems.
- To gain knowledge in simulation techniques of flexible manufacturing systems.
- To outline computer software and database of flexible manufacturing systems.
- To familiarize the principles of just in time manufacturing systems.

Course Outcome – Cos		Cognitive Skill
CO-01	Describe the areas of Competitive Environment and the best Manufacturing Practices in the World.	U
CO-02	Perceive concepts of Group Technology and Flexible Manufacturing Systems.	A
CO-03	Acquaint with Simulation of Flexible Manufacturing Systems.	U
CO-04	Evaluate Computer Software and Database of Flexible Manufacturing Systems.	E
CO-05	Explain Just in Time Manufacturing Systems.	R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	M	S	S	S	L	M	L
CO-02	M	M	M	S	S	M	L	M	L
CO-03	L	S	M	S	S	S	L	M	L
CO-04	L	S	M	S	S	S	L	M	L
CO-05	M	M	M	S	S	M	L	M	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: MANUFACTURING IN A COMPETITIVE ENVIRONMENT 9

Introduction – Competitiveness - Cost, Time, Quality, Flexibility - Product flexibility, Operation flexibility, Capacity flexibility - Automation of Manufacturing Process - Numerical Control - Adaptive Control - Material Handling and Movement - Industrial Robots - Sensor Technology - Flexible Fixtures - Design for Assembly, Disassembly and Service – Product Lifecycle Management.

UNIT II: GROUP TECHNOLOGY & FLEXIBLE MANUFACTURING SYSTEMS 9

Part Families – Classification and Coding – Production Flow Analysis – Machine Cell Design – Benefits – Components of Flexible Manufacturing Systems (FMS) – Computer Control and Functions – Planning, Scheduling and Control of FMS – Knowledge Based Scheduling.

UNIT III: SIMULATION OF FLEXIBLE MANUFACTURING SYSTEMS 9

Introduction - Application of Simulation – Simulation Process - Stating the Project's Objective(s), Building the Abstract Model, Input Analysis, Building the Simulation Model, Model Verification, Model Validation, Output Analysis - Model of FMS - Simulation Software – Limitations-Case studies.

UNIT IV: COMPUTER SOFTWARE AND DATABASE OF FLEXIBLE MANUFACTURING SYSTEMS 9

FMS Software - Introduction, General Structure and Requirements, Functional Descriptions, Operational Overview, Types of Software Specification and Selection - Trends. Manufacturing Data Systems - Data Flow - FMS Database Systems – Computer Aided Design/Computer Aided Manufacturing Considerations - Planning for FMS Database.

UNIT V: JUST IN TIME MANUFACTURING SYSTEMS 9

Toyota Production System (TPS): An overview, Components - Introduction to Lean Manufacturing, Comparison of TPS and Lean - Three Ms - Muda, Mura and Muri - Push versus Pull Systems - Types of Kanbans - Kanban Planning and Control Models - Signal Kanban - Other types of Kanbans - Express Kanban - Emergency Kanban - Through Kanban - Level Schedules for Mixed Model Assembly Lines - Alternative JIT Systems - Just-in-time (JIT) Purchasing - Total Quality Control and JIT - JIT Implementation - Barriers, Potential Benefits.

TOTAL: 45 PERIODS

REFERENCES:

1. Groover M.P., " Automation, Production Systems and Computer Integrated Manufacturing ", Third Edition, Prentice-Hall, 2007.
2. Jha, N.K. “Handbook of Flexible Manufacturing Systems ", Academic Press Inc. Reprint, 2021.
3. Kalpkjian, “Manufacturing Engineering and Technology ", 3 rdedition,Addison-Wesley Publishing Co., 2020.
4. Pascal Dennis, “Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System”, (Fifth edition), Productivity Press, New York, 2020.
5. Taiichi Ohno, Toyota, " Production System Beyond Large-Scale production Productivity Press (India) Pvt.Ltd. 2021.

CM4507	MECHATRONICS IN MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To know the basic working principle of sensors and transducers of use for manufacturing systems
- To know the basic working principle of drives and actuators of use for manufacturing systems
- To know the features, modules and interfaces of microcontrollers and microprocessors
- To gain the knowledge of integration of mechatronic systems in automation of modern manufacturing systems

Course Outcome – Cos		Cognitive Skill
CO-01	Imply the knowledge to study the mechatronics in modern manufacturing systems.	A
CO-02	Identify and select the sensors and transducers based on the application.	E
CO-03	Identify the principles and functions of drives and actuators.	E,A
CO-04	Get knowledge of microprocessor and microcontrollers and its functions.	R
CO-05	Apply the knowledge about integration of mechatronic systems in manufacturing.	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	M	L	S	M	M	M	N	M	L
CO-04	M	M	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO MECHATRONICS IN MODERN MANUFACTURING 12

Introduction to Process Parameters in Conventional Manufacturing – Assembly – Inspection – Transportation - Introduction to Systems - Subsystems of Mechatronics - Identification of Mechatronics' Entities in Modern Manufacturing - Mechanical, Fluid, Thermal, Electrical, Electronics, Communication, Control systems and Software Integration for Manufacturing - Classification of Manufacturing based on Mechatronics – CNC based Subtractive Manufacturing – Rapid Prototyping based Additive Manufacturing- Automated Assembly Stations – Modern Quality Inspection and Transportation Systems.

UNIT II: SENSORS AND TRANSDUCERS 8

Introduction – Performance Terminology – Resistive Transducers – Inductive Transducers - Capacitance Transducers – Optical Sensors – Contact and Non-Contact Temperature Sensors – Eddy Current Sensor – Hall Effect Sensor – Piezo Electric Sensor - Ultrasonic Sensors – Proximity Sensors – Chemical and Gas Sensors - Signal Conditioning - Condition Monitoring

UNIT III: DRIVES AND ACTUATORS 8

Role of Linear and Rotary Actuators - Electrical Actuators- Servo Concepts and Stepper Motors - Fluid Power – Piezo Actuators – Solenoids - Function of Drives - Mechanical Switching Devices – Solid State drives for various actuators

UNIT III: MICROPROCESSORS AND MICROCONTROLLERS 8

Requirement for Processor – Comparison of 8085 Microprocessor and 8051 Microcontrollers– 8051 Microcontrollers Architecture -Assembly Language Programming- Instruction Set, Addressing Modes, Basic Programming – Interfacing - Sensors, Keyboard, LED, LCD, A/D and D/A Converters, Actuators – Embedded Systems

UNIT V: INTEGRATION OF MANUFACTURING SYSTEMS 9

Design Process - Stages of Design Process – Skeletal Structure and Block Diagram of CNC Based - Vertical Machining Centre, turning centre, Water Jet Machine, Electrical Discharge Machine, Serial Manipulator, hydraulic press, 3 D printers– Coordinate Measuring Machine –Automated conveyors - Extended Transportation System – Total Integration of Manufacturing Systems for Production Automation

TOTAL: 45 PERIODS

REFERENCES:

1. Beno Benhabib, Manufacturing, design, production, automation and integration, Marcel Dekker, 2020
2. Bolton W, ― Mechatronics: Electronic control systems in mechanical and electrical engineering, 6thedition, Pearson Education Limited, 2022.
3. Devadas shetty, Richard A. Kolk, Mechatronics System Design, Cengage Learning, 2011.
4. Mazidi M A and Mazidi J G, 8051 Microcontroller and Embedded Systems, 2022.
5. Vijayaraghavan G.K., Balasundaram M S, Ramachandran K P, Mechatronics: Integrated Mechanical Electronic Systems, Wiley, 2016.

CM4572	ADVANCED METROLOGY LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To introduce the practical applications of various measurement concepts.
- To gain knowledge on the design perspective of advanced measuring machines.
- To make the students understand the fundamental principles of measuring techniques by practicing exercises on various measuring instruments.
- To perform metallographic study of the given samples and heat treatment study of steel.
- To familiarize the importance of measurement and inspection in manufacturing industries.

Course Outcome – Cos		Cognitive Skill
CO-01	Demonstrate sophisticated measuring machines with ease.	A
CO-02	Improve the confidence in developing of new concepts and new measuring machines.	E
CO-03	Develop various technical terms and perform measurement tasks accurately.	E
CO-04	Indentify the right instrument and method of measurement for a particular Application.	S
CO-05	Apply the fundamental concepts of measurements, standards, calibrations, maintenance of laboratory facilities and handling of equipment's.	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	M	S	M	M	M	M	N	M	M
CO-02	M	S	L	M	M	M	N	L	L
CO-03	M	S	S	M	M	M	N	M	L
CO-04	M	S	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

LIST OF EXPERIMENTS:

1. Calibration of comparators using slip gauges
2. Assessment of gauge surfaces using optical flats
3. Measurement of Surface roughness of specimens using contact method
4. Non-contact surface roughness measurement of specimens
5. Counting of fringes produced by Michelson's interferometer
6. Measurement of dimensional features using machine vision system
7. Study exercises on clean room behaviour
8. Roundness and cylindricity measurement of components
9. Study on flatness measurement of surface using autocollimator
10. Measurement of dimensional features of a specimen - Contact type using CMM.

TOTAL: 60 PERIODS

SEMESTER III

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
THEORY						
1.	CM4508	Design for Manufacturing and assembly Systems	3	0	0	3
2.	CM45XX	Elective VI (Open Elective)	3	0	0	3
PRACTICAL						
3.	CM45P1	Preliminary work on Dissertation	0	0	18	6
Total			**6**	**0**	**18**	**12**

CM4508	DESIGN FOR MANUFACTURING AND ASSEMBLY	L	T	P	C
		3	**0**	**0**	**3**

OBJECTIVES

- Understanding the general design rules for manufacturability
- Applying the production process for ease of manufacturing.
- Analyze factors for selection of metals and alloys and relationship to manufacturing processes
- Apply the concepts of design for manufacturing and assembly for product manufacturing.
- Compare various manufacturing processes and assembly techniques required for product development.

Course Outcome – Cos		Cognitive Skill
CO-01	Understand to relate design rules for manufacturability.	U
CO-02	Apply design rules for ease of machining.	A
CO-03	Enumerate the general design considerations for casting, casting tolerances.	E
CO-04	Remember Design factors for forging.	U
CO-05	Apply design guidelines to assembly.	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO/CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	L	N	M	M
CO-02	S	L	M	M	M	L	N	L	L
CO-03	M	L	M	M	M	L	N	M	L
CO-04	M	L	M	S	M	L	N	M	M
CO-05	M	L	M	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT – I Introduction: **9**

Design Philosophy, steps in design process, General design rules for manufacturability; Basic principles of designing for economical production-creativity in design Materials: Selection of materials for design, Developments in materials technology, Criteria for materials selection, Material selection inter relationship with process selection

UNIT-II Machining process: **9**

Over view of various machining processes. General design rules for machining, Dimensional tolerance and surface roughness, Design for machining ease, Redesign of components for Machining ease with suitable examples, General design recommendations for machined parts.

UNIT – III Metal casting: **9**

Appraisal of various casting processes; selection of casting process, general design considerations for casting, casting tolerances, use of solidification simulation in casting design, product design rules for sand casting Metal joining: Appraisal of various welding processes, factors in design of weldments, general design guidelines, pre and post treatment of welds, effects of thermal stresses in welded joints, design of brazed joints

UNIT IV Forging: **9**

Design factors for forging, closed die forging, design parting lines of dies, drop forging die design, General design recommendations. EXTRUSION: Sheet metal work and plastics, Design guide lines for extruded sections, Design principles for punching, blanking, bending, deep drawing, Keeler -Goodman formability diagram,(forming limit diagram) Component design for blanking.

UNIT V Design for assembly: **9**

General design guidelines for manual assembly, Development of systematic DFA methodology, Assembly efficiency, Classification system for manual handling, Classification system for manual insertion and fastening, Effect of part symmetry on handling time.

REFERENCE BOOKS:

1. A. K. Chitale and R.C. Gupt ‘‘Product design and Manufacturing” –Prentice-Hall of India, New Delhi, 2020.
2. Kevin Otto and Kristin Wood, ”Production Design”, Person Education, 2021.
3. Surender Kumar, Goutham Sutradhar, ‘‘Design and Manufacturing”, oxford & IBH Publishing co, Pvt Ltd, 2005.

TOTAL: 45 PERIODS

CM45P1	PRELIMINARY WORK ON DISSERTATION	L	T	P	C
		0	0	18	6

OBJECTIVES:

- To improve the skills in reading technical magazines, conference proceedings and
- journals.
- To develop the skill of identifying research problems/projects in the field of Thermal
- Engineering.
- To familiarize with the design and analysis tools required for the project work and plan the
- experimental platform, if any, required for project work.

GUIDELINES

- Each student has to identify the topic of project related to the field of Thermal Engineering.
- The candidate has to be in regular contact with his guide and the topic of dissertation must
- be mutually decided by the guide and student.
- The topic has to be approved by a review committee constituted by the department.
- The work has to be presented periodically in front of the review committee.
- The preparation of report consisting of a detailed problem statement and a literature
- review.
- The preliminary results (if available) of the problem may also be discussed in the report.
- The project report should be presented in standard format as provided by the Noorul Islam centre for Higher Education

EVALUATION

- Preliminary work on dissertation (Project Work Phase – I) evaluation is based on Regulations of Post graduate programmes of Noorul Islam Centre for Higher Education.

OUTCOMES:

The students would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized coordinated in their dissertation (project work phase – II).

TOTAL: 90 PERIODS

SEMESTER IV

SL. NO.	COURSE CODE	COURSE TITLE	L	T	P	C
1.	CM45P5	Dissertation	0	0	36	18
Total			**0**	**0**	**36**	**18**

CM45P5	DISSERTATION	L	T	P	C
		0	**0**	**36**	**18**

OBJECTIVES:

- To improve the skills in publishing technical papers in conference proceedings and
- journals.
- To produce factual results of their applied research idea in the Computer Integrated Manufacturing field, from preliminary work on dissertation (phase-I).

OUTCOMES:

The students would apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative, well planned, organized, coordinated project outcome of the aimed work.

GUIDELINES

- Each student has to complete dissertation (project phase II) under the guidance of a faculty member, as specified in preliminary work on dissertation (Phase I).
- The candidate has to be in regular contact with his guide and the topic of dissertation must
- be mutually decided by the guide and student.
- The topic has to be approved by a review committee constituted by the department.
- The work has to be presented periodically in front of the review committee.
- The candidate has to prepare a detailed project report consisting of introduction of the
- problem, problem statement, literature review, objectives of the work, methodology
- (experimental set up or numerical details as the case may be) of solution and results and
- discussion.
- The report must bring out the conclusions of the work and future scope for the study.
- The project report should be presented in standard format as provided by the Noorul Islam Centre for Higher Education.

EVALUATION

Dissertation (Project Work Phase – II) evaluation is based on regulations of Post graduate programmes of Noorul Islam Centre for Higher Education. Students should attend an international conference and publish a paper in the conference proceeding/reputed journal before attending the viva voce examination.

TOTAL: 180 PERIODS

CORE ELECTIVES

Sl.No	COURSE CODE	COURSE NAME	L	T	P	C
42.	CM45A1	Computer Aided Process Planning	3	0	0	3
43.	CM45A2	Design for Manufacturing	3	0	0	3
44.	CM45A3	Design of Cellular Manufacturing System	3	0	0	3
45.	CM45A4	Finite Element Analysis in Manufacturing Engineering	3	0	0	3
46.	CM45A5	Advances in Welding and Casting Technology	3	0	0	3
47.	CM45A6	Precision Engineering	3	0	0	3
48.	CM45A7	Manufacturing Management	3	0	0	3
49.	CM45A8	Applied Materials Engineering	3	0	0	3
50.	CM45A9	Micro and Nano Manufacturing	3	0	0	3
51.	CM45B1	Lean Manufacturing and Six Sigma	3	0	0	3
52.	CM45B2	Machine Learning	3	0	0	3
53.	CM45B3	Computer Applications in Design	3	0	0	3
54.	CM45B4	Research Methodology and IPR	3	0	0	3
55.	CM45B5	Industrial Robotics and expert systems	3	0	0	3
56.	CM45B6	Additive Manufacturing	3	0	0	3
57.	CM45B7	MEMS and Nanotechnology	3	0	0	3
58.	CM45B8	Polymers and Composite Materials	3	0	0	3
59.	CM45B9	Material Characterization Techniques	3	0	0	3
60.	CM45C1	Manufacturing System Simulation	3	0	0	3
61.	CM45C2	Data Analytics	3	0	0	3
62.	CM45C3	Internet of Things for Manufacturing	3	0	0	3
63.	CM45C4	Warehouse Layout Planning and Part Feeding Methods	3	0	0	3
64.	CM45C5	Total Quality Systems and Engineering	3	0	0	3

65.	CM45C6	Tool Engineering	3	0	0	3
66.	CM45C7	Green Manufacturing	3	0	0	3
67.	CM45C8	Sensors for Manufacturing and Condition Monitoring	3	0	0	3
68.	CM45C9	Reliability and Total Productive Maintenance	3	0	0	3
69.	CM45D1	Project Management	3	0	0	3
70.	CM45D2	Advanced Machine Tool Design	3	0	0	3
71.	CM45D3	Management of Manufacturing Systems	3	0	0	3
72.	CM45D4	Design of Fluid Power Systems	3	0	0	3
73.	CM45D5	Electronics Manufacturing Technology	3	0	0	3
74.	CM45D6	Environment Conscious Manufacturing	3	0	0	3
75.	CM45D7	Evolutionary Computation	3	0	0	3
76.	CM45D8	Sustainable Manufacturing	3	0	0	3
77.	CM45D9	Intelligent Product Design and Manufacturing	3	0	0	3
78.	CM45E1	Intelligent Manufacturing Systems	3	0	0	3
79.	CM45E2	Enterprise Resource Planning	3	0	0	3
80.	CM45E3	Micro Electro Mechanical Systems	3	0	0	3
81.	CM45E4	Product Lifecycle Management	3	0	0	3
82.	CM45E5	Industry 4.0	3	0	0	3

CM45A1	**Computer Aided Process Planning**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To familiarize the students with the basics of process planning.
- To introduce the part representation methods and approaches.
- To acquaint the students with knowledge in process metrics and capabilities.
- To gain knowledge on Logical Design of Process Planning.
- To impart knowledge on the types of computer aided process planning systems.

Course Outcome		Cognitive Skill
CO-01	Elaborate on the basics of process planning.	U
CO-02	Demonstrate competency in part representation methods and approaches	R
CO-03	Recognize the importance of process metrics and capabilities	U
CO-04	Elaborate on Logical Design of Process Planning	A
CO-05	To impart knowledge on the types of computer aided process planning systems	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction: 9

Production Planning and Process Planning -The role of Process Planning in the Manufacturing cycle – Experience based planning - Need for computer aided process planning. – Process Planning and Concurrent Engineering, Group Technology

Unit II: Part Design Representation 9

Basic part representation methods: CAD models - Feature based design - Design interface: syntactic pattern recognition-State transition diagram-Decomposition approach-Logical approach-Graph based approach.

Unit III: Knowledge Representation 9

Process knowledge - Dimensions and tolerances - Surface Properties - Process Constraints - Process Economics - Process capability.

Unit IV: System Formulation 9

Logical Design of Process Planning – System structure-planning strategy - declarative knowledge of part- procedure knowledge of planning-other issues: process parameter selection, tool selection, machine selection, plan optimization, Implementation considerations – Decision table and Decision trees.

Unit V: Computer Aided Process Planning Systems 9

Computer aided Process Planning – Variant process planning – Generative process planning – Forward and backward planning, input format - Totally Integrated process planning systems – Expert process planning-Commercial systems: CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.

TOTAL: 45 PERIODS

REFERENCES:

1. Chang,T.C.andWysk,R.A., "An Introduction to automated process planning systems",PrenticeHall,1985.
2. Chang,T.C., "An Expert Process Planning System", PrenticeHall, 2020.
3. Halevi,G. and Weill,R.D., "Principles of Process Planning", A logical approach– Springer,2003.
4. Rao., "Computer Aided Manufacturing", Tata McGraw-Hill Publishing Co.2002.
5. Singh,N., "Systems Approach to Computer Integrated Design and Manufacturing",JohnWiley&Sons,2020.

Vollmann, T.E. and Bery, W.E., "Manufacturing Planning and Control Systems, 5thEdition. GalgotiaPublications, 2020.

CM45A2	Design for Manufacturing	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To discuss system implementation by considering various manufacturing constraints.
- To impart the knowledge in design for manufacturing and assembly (DFM/A) principles.
- To be acquainted with the use of DFM/A tools.
- To elaborate DFM/A system architecture.
- To outline product model and interfacing.

Course Outcome		Cognitive Skill
CO-01	Describe the design for manufacturing principles.	U
CO-02	Implement DFM/A principles in the required applications.	R
CO-03	Use DFM/A tools.	U
CO-04	Select appropriate DFM/A system architecture with the given manufacturing aspects.	A
CO-05	Create Product model.	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction: 9

Implementation of concurrent engineering - Issues involved in introducing design for manufacturing and assembly (DFM/A) - DFM/A principles and techniques - Current state of commercial DFM/A packages-Requirements for a new generation of DFM/A Systems-Knowledge - based approaches to DFM/A - Interfacing design (CAD)and DFM/A Systems, Case studies.

UNIT II: DFM/A Methodologies 9

Total design Environment - Tools: Quality function deployment, Failure modes and effects analysis (FMEA) - Design for manufacturing and assembly principles: Mechanical Assembly – General DFA principles - DFA guidelines: General mechanical, General electro – mechanical - Design for manual assembly - Design for electronics Assembly - Design for Testability – Machining - Currently available manufacturability analysis tools - Integrating FM/A into different design regimes - Case studies.

UNIT III : DFM/A System Architecture 9

System of system design Scenario— Manufacturing Aspects – Design - Analysis-Methods of data representation - Object - oriented Approach - Databases - Design for Manufacturing - Design for Assembly - Conceptual architecture - Analysis and integration and inference – Interfaces - Analysis engine concepts - Process model - Control and system operation - Control issues

UNIT IV ;Product Model And Cad Interfacing 9

Product Model - Structure and object - Oriented Approach-Classes and objects - Polymorphism and inheritance-Modelling concepts- Product model structure overview- Detailed product model-Storage of object Oriented product models-Features in CAD-DFM integration-Feature representation methodologies-Classification of features-Hierarchical structure of the features-Interfacing with different CAD systems – Interface mechanisms for applications-knowledge engineering and inference

UNITV:System Implementation 9

System for design for PCB assembly, small parts assembly, mechanical assembly, machining Generic architecture operational aspects-Architecture realization-Control module.

TOTAL: 45 PERIODS

REFERENCES:

1. Chang,T.C.andWysk,R.A., “An Introduction to automated process planning systems”,PrenticeHall,1985.
2. Chang,T.C., “An Expert Process Planning System”, PrenticeHall, 2020.
3. Halevi,G. and Weill,R.D., “Principles of Process Planning”, A logical approach– Springer,2003.

4. Rao., “Computer Aided Manufacturing”, Tata McGraw-Hill Publishing Co.2002.
5. Singh,N., “Systems Approach to Computer Integrated Design and Manufacturing”,JohnWiley&Sons,2020.

Vollmann, T.E. and Bery, W.E., “Manufacturing Planning and Control Systems, 5thEdition. GalgotiaPublications, 2020.

CM45A3	Design of Cellular Manufacturing system	L	T	P	C
		3	0	0	3

OBJECTIVES :

- To introduce the concept of group technology
- To expose students to planning and design of cellular manufacturing system
- To impart knowledge on implementation of group technology/cellular manufacturing systems
- To outline the concept of performance measurement and control of GT/CMS
- To gain knowledge on economics of GT/CMS.

Course Outcome		Cognitive Skill
CO-01	Perceive the concept of group technology	U
CO-02	Implement DFM/A principles in the required applications.	R
CO-03	Understand the planning and design of CMS	U
CO-04	Analyse the performance measurement and control of GT/CMS.	A
CO-05	Describe the economics of GT/CMS	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction: **9**

Introduction to Group Technology, Limitations of traditional manufacturing systems, characteristics and design of groups ,benefits of GT and issues in GT.

UNIT II: Cms Planning And Design **9**

Problems in GT/CMS- Design of CMS-Models, traditional approaches and non-traditional approaches-Genetic Algorithms, Simulated Annealing, Neural networks.

UNIT III : Implementation Of Gt/Cms **9**

Inter and Intracell layout, cost and non-cost-based models, establishing a team approach, Managerial structure and groups, batch sequencing and sizing, life cycle issues in GT/CMS

UNIT IV ; Performance Measurement And Control **9**

Measuring CMS performance-Parametric analysis-PBC in GT/CMS, cell loading, GT and MRP-framework.

UNITV: Economics Of Gt/Cms: **9**

Conventional Vs group use of computer models in GT/CMS, Human aspects of GT/CMS-cases.

TOTAL: 45 PERIODS

REFERENCES:

1. Chang,T.C.andWysk,R.A., "An Introduction to automated process planning systems",PrenticeHall,1985.
2. Chang,T.C., "An Expert Process Planning System", PrenticeHall, 2020.

3. Halevi,G. and Weill,R.D., “Principles of Process Planning”, A logical approach– Springer,2003.
4. Rao., “Computer Aided Manufacturing”, Tata McGraw-Hill Publishing Co.2002.
5. Singh,N., “Systems Approach to Computer Integrated Design and Manufacturing”,JohnWiley&Sons,2020.
6. Vollmann, T.E. and Bery, W.E., “Manufacturing Planning and Control Systems, 5thEdition. GalgotiaPublications, 2020.

CM45A4	Finite Element Analysis in Manufacturing Engineering	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To equip students with fundamental of inter element principles.
- To impart knowledge on solving dimensional finite element problems.
- To develop finite element model for the field problems.
- To introduce on-linear analysis and its computational methods.
- To emphasis on the finite element approach of production processes.

Course Outcome		Cognitive Skill
CO-01	Demonstrate finite element analysis techniques	U
CO-02	Solve two dimensional finite element problems	A,R
CO-03	Analyze of field problems for shape function	U
CO-04	Determine the computational solution techniques for nonlinear problems	A
CO-05	Apply finite element analysis techniques to analyse the production processes.	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: General Introduction: **9**

Historical Background–Mathematical Modeling of field problems in Engineering–Governing Equations-Discrete and continuous models— Boundary, Initial and Eigen Value problems–Variational Formulation of Boundary Value Problems – Ritz Technique –Natural and Essential Boundary conditions –Basic concepts of the Finite Element Method .One Dimensional Second Order Equations–Discretization-element types- Linear and Higher order Elements — Derivation of Shape functions and Stiffness matrices and force vectors- Assembly of Matrices-solution of problems from solid-Structural ,stress, and strain analysis–Introduction to beam elements.

UNITII: Problem In 2d **9**

Second Order 2D Equations involving Scalar& Vector Variables – Variational formulation – Finite Element formulation–Triangular elements–Shape functions and element matrices and vectors .Application to Field Problems in Manufacturing Engineering - Quadrilateral elements. Introduction to elasticity equations–stress strain relations–plane problems of elasticity–element equations Plane stress, plane strain and axisymmetric problems — stress-strain-time or constitutive equations- Introduction to flow problems-solution of problems in fluid mechanics-numerical examples-plates and shell.

UNITIII: Applications of field problems **9**

Higher Order Elements. Natural co-ordinate systems– Iso parametric elements– Shape functions for isoperimetric elements— One, two and three dimensions— Serendipity elements— Numerical integration and application to plane stress problems transformation – Jacobian of transformation-order of convergence- numerical integration –example problems-shape functions innaturalcoordinates-rectangularelements-Lagrangefamily-Serendipity family-rectangular prisms-Tetra hedral elements

UNIT IV: Nonlinear analysis **9**

Introduction to Non-linear problems-some solution techniques-computational procedure-simple

material nonlinearity- Plasticity and visco plasticity, stress stiffening, contact interfaces- problems of gaps and contact-geometric non-linearity-modeling considerations-Impact analysis.

UNIT V: Analysis Of Production Processes **9**

Application to Bulk forming, sheet metal forming, casting, metal cutting, welding- Features of software packages

TOTAL: 45 PERIODS

REFERENCES:

1. Bathe,K.J.,"FiniteElementProceduresinEngineeringAnalysis,1990.
2. Kobayashi,S.Soo-IK-OhandAltan,T.,"MetalformingandtheFiniteelementMethods",OxfordUniversity Press,2020.
3. Lewis,R.W.,Morgan,K,Thomas,H.R.andSeetharaman,K.N., "TheFiniteElementMethodinHeatTransferAnalysis",JohnWiley,1994.
4. Rao, "Finite Element Method in Engineering",Pergammon Press,2020.
5. Reddy,J.N,"AnIntroductiontotheFiniteelementMethod",McGraw–Hill,2005.

CM45A5	ADVANCES IN WELDING AND CASTING TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on Metallurgy of welding.
- To be acquainted with Special welding processes.
- To elaborate system design and metallurgy.
- To provide knowledge on Special casting processes.
- To familiarize the students with automation and environmental aspects of welding and casting

Course Outcome		Cognitive Skill
CO-01	Use design knowledge to overcome defects in welding.	U
CO-02	Select suitable welding process for the given applications	A,R
CO-03	Use design knowledge to produce quality casting.	U
CO-04	Select suitable casting process for the given applications	A
CO-05	Implement automation principles with environment consciousness techniques in welding and casting plants	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Welding Design: **9**

Introduction - Fusion zone – Heat flow in welding -Weld solidification --Weldability of steels – Cast iron -Stainless steels, aluminum, copper and titanium alloys - Pre and Post weld heat treatments - Weld joint design-residual stress-Testing of Welding joints-Weld defects–Case study on welding design

Unit II: Special Welding Processes **9**

Principles, Equipment, Types, Advantages and Limitations of High frequency induction welding, Diffusion bonding, Cold pressure welding, Friction welding, Explosive welding, Plasma arc welding, Ultrasonic welding, Electron beam welding and Laser beam welding

Unit III: Casting Design **9**

Introduction - Solidification shrinkage- - Pattern allowances- Design of gating System-Design of thin and unequal sections -Rapid solidification processing (RSP) - Melt spinning -Roll quenching – Vibratory solidification -Splat cooling –Thixo forming — Rheocasting - Single crystal growing Casting defects, inspection, diagnosis and rectification–Case study on casting design..

Unit IV: Special Casting Processes **9**

Evaporative Pattern Casting Process and full mould process — Vaccum sealed moulding—vacuum casting - Magnetic Moulding - Squeeze Casting-types - Plaster mould casting - Ceramic mould casting-Investment casting-Shell Moulding-Continuous casting-Electro slag casting.

Unit V:Automation And Environmental Aspects Of Welding And Casting **9**

Mechanization and automation in foundries: Sand Plant, Material Handling, Mould and Core Making-Pollution control, energy and waste management in foundries. Automated welded joint-Welding robots, Positioners and Manipulators-Microprocessor based control of resistance and arc welding-Arc sensing, Weld Seam Tracking and Vision system-Effects of welding fusion environment.

TOTAL: 45 PERIODS

REFERENCES:

1. American Welding Society,"Welding Handbook",Volume1-5, 9th Edition,2020.
2. DieterRadaj, "Design and Analysis of Fatigue Resistant Welded Structures",Woodhead Publishing,United Kingdom,1990,ISBN:978-1855730045.
3. JohnCampbell,"Complete Casting Handbook: Metal Casting Processes, Metallurgy,Techniques and Design", 2nd edition, Butterworth-Heinemann., United Kingdom, 2015, ISBN:978-1856178099.
4. MahiSahoo and SamSahu,"Principles of Metal Casting",McGraw-Hill Education, UnitedStates, 3rd Edition,2014,ISBN:978-0071789752.
5. Robert B. Tuttle, "Foundry Engineering: The Metallurgy and Design of Castings", Create Space Independent Publishing Platform, Amazon, 2012, ISBN: 9781478157434.

CM45A6	Precision Engineering	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To gain knowledge of the need for precision engineering and its application.
- To familiarize the importance of materials in precision engineering.
- To introduce latest topics in manufacturing like micro machining and MEMS in order to equip the join core manufacturing industries.
- To impart knowledge about the causes of errors and their remedies.
- To introduce the students with elements used in precision machines

Course Outcome		Cognitive Skill
CO-01	Understand the need of precision engineering and its application.	U
CO-02	Discuss process knowledge to use the light material	A,R
CO-03	Discuss the advanced precision machining processes	U
CO-04	Explain the various errors, its causes and remedies to overcome these.	A
CO-05	Describe elements used in precision machine tool.	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction: **9**

Accuracy and Precision– Need for high precision –concept of accuracy - tolerance and fits system –Hole and shaft system–accuracy of manufacturing processes–types off its–Selective assembly

Unit II: Materials For Precision Engineering **9**

Diamond - types-single crystal - PCD - Natural-synthetic CBN - Ceramics - coated metals and non-metals-High performance polymer-alloys-refractory metals: cutting tools— performance –components of instruments-Jewels-self Lubrication-smart materials-properties-testing-applications..

Unit III: Precision Machining **9**

Precision grinding: IC chip manufacturing-ELID process-a spherical surface generation Grinding wheel-Designer and selection of grinding wheel-High-speed grinding-High-speed milling-Micro machining - Diamond turning-MEMS - micro finishing process — surface roughness measures – concept and non-concept method-comparison of features with machining process.

Unit IV: Errors: Causes And Remedies **9**

Static stiffness - influence on machining accuracy - over all stiffness in a machine/instrument – errors due to variation of cutting forces-clamping forces-errors due to compliance while machining. Inaccuracy due to thermal effects: Heat sources and dissipation - Geometry of thermal deformation —Influence of forced is statics dimensional wear of elements - instruments; Machining tools and their influence on accuracy-error due to clamping and setting location.

Unit V: Precision Machine Elements **9**

Introduction- guide ways- Drive systems; rolling element bearings-Principles, construction, classification, application etc.,-Lubricated sliding bearings-construction-Principles etc.,-Hydrostatics bearings-types-aerostatic bearings-linear drive motors-magnetic bearings-applications-limitations-advantages.

TOTAL: 45 PERIODS

REFERENCES:

1. JamesD. And Meadow,S.,"Geometric Dimensioning and Tolerancing", MarcelDekkerInc.,1995.
2. JuliarW.Gardner, andVijayK.Varadan,"MicroSensors, MEMS and Smart

Devices",JohnWileyandSons,2001.

3. MurthyR.L.,"Precision Engineering in Manufacturing",New age International Publications,NewDelhi,Firstedition1996; Reprint2005.
4. PauloDavim" Microfabrication and Precision Engineering: Research and Development", Woodheadpublishing, 2020. VenkateshV.C.andSudinI.,"Precisionengineering",TataMcGrawHillCo.,NewDelhi, 2020

CM45A7	Manufacturing Management	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Students will be able to study the concepts in facility planning.
- Students will be able to study types of plant layout and capacity planning methods.
- Students will be able to study the concepts of Project management.
- Students will be able to study the concepts and methods in production planning and control.
- Students will be able to study the concepts in Inventory and maintenance management.

Course Outcome		Cognitive Skill
CO-01	Able to acquire knowledge on facility, and problems associated with it	U
CO-02	Ability to learn the various capacity and layout planning models	A,R
CO-03	Understand the concepts of demand forecasting and project management with relevant case studies.	U
CO-04	Able to understand the concepts of production planning and scheduling.	A
CO-05	Understand the various inventory and maintenance management techniques.	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Facility Planning **9**

Facility planning– Factors affecting selection of plant location, Factor rating analysis: Break–even analysis, Load distance model, closeness ratings–case study

Unit II: Capacity& Layout Planning **9**

Types of plant layout, criteria for good layout, Process layout, Assembly line balancing. Computer based solutions to layout problems such as CRAFT, ALDEP, CORELAP and PREP. Capacity planning— Analysis of designed capacity, installed capacity, commissioned capacity, utilized capacity, factors affecting productivity and capacity expansion strategies.

Unit III: Project Management **9**

Demand forecasting – Quantitative and qualitative techniques, measurement of forecasting errors, Project management — its role in functional areas of management, network representation of a project, CPM and PERT techniques –case study.

Unit IV: Production Planning& Control **9**

Aggregate production planning, production planning strategies, Disaggregating the aggregate plan, Materials Requirement Planning (MRP), MRP-II, Supply chain management, Operation scheduling, prioritization.

Unit V: Inventory And Maintenance Management **9**

Introduction to EOQ models, Inventory control techniques – ABC, FSN, VED etc. Types of

inventory control — Perpetual, two-bin and periodic inventory system — JIT, SMED, Kanab, Zero inventory, Maintenance strategies and planning, Maintenance economics: quantitative analysis, optimal number of machines, Replacement strategies and policies – economic service life, opportunity cost, replacement analysis using specific time period.

TOTAL: 45 PERIODS

REFERENCES:

1. Chary,SN ,"Production and Operations Management",4th Edition,SIE,TMH, 2020.
2. Chase.RB,N.J.Aquilano,&F.R.Jacobs, "Operations Management For Competitive Advantage" ,11th Edition,SIE,TMH,2020.
3. James.B.Dilworth, "Operations Management–Design, Planning and Control for Manufacturing and Services",McGrawHillInc. Management Series, 1992.
4. KanishkaBedi, "Production and Operations Management", 2nd Edition, Oxford Higher Education, 2007.
5. Lee.J.Krajewski,L.P.Ritzman,&M.K.Malhothra,"Operations Management– ProcessandValueChains",8th Edition,PHI/PearsonEducation,2007.
6. MelnykDenzler,"Operations\Management ValueDrivenApproach",IrwinMcGrawHill,1996.

Pannererselvam,R"ProductionandOperationsManagement",3rd Edition,PHI,2012.

CM45A8	APPLIED MATERIALS ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To provide knowledge in the areas of elastic and plastic behaviour of materials.
- To understand the fracture behaviour of materials.
- To elaborate the theories on plastic forming.
- To classify the different types of advanced materials.
- To select the material for specific industrial applications.

Course Outcome		Cognitive Skill
CO-01	Discuss elastic plastic behavior of metals and its strengthening mechanism	U
CO-02	Behaviour of metals and give solutions to avoid them.	A,R
CO-03	Create processing techniques for controlling shape of the final product.	U
CO-04	Able to understand he concepts of production planning and scheduling.	A
CO-05	Select suitable materials for the specific industrial applications.	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	M	S	S	S	L	M	L
CO-02	M	M	M	S	S	M	L	M	L
CO-03	L	S	M	S	S	S	L	M	L
CO-04	L	S	M	S	S	S	L	M	L
CO-05	M	M	M	S	S	M	L	M	L

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Elastic And Plastic Behaviour: **9**

Elastic, plastic and elastic and viscoelastic Behavior-Mechanism of Elastic and Plastic deformation, Shear strength of perfect and real crystals - Deformation by slip and twinning, strengthening mechanism, solid solution, grain boundary, poly phase mixture, precipitation, particle, fibre and dispersion strengthening, work hardening-Effect of temperature, strain and strain rate on plastic behavior

Unit II: Fracture Behaviour **9**

Types of fracture -Griffith's theory, dislocation theory, ductile to brittle transition in steel — Stress intensity factor, fracture toughness and toughening mechanisms -High temperature fracture, creep - Larson-Miller Parameter - Deformation and fracture mechanism maps - Fatigue. Low and high

cycle fatigue test, crack initiation and propagation mechanisms and Paris law, Effect of surface and metallurgical parameters on fatigue failure

Unit III: Plastic Forming Of Metals **9**

Fundamentals of metal working, mechanics of metal working, flow-stress distribution, residual stresses, temperature in metalworking-Forging in plane strain, open and closed die forging-Forces and geometrical relationships in rolling, theories of cold and hot rolling, bending and stretch forming.

Unit IV: Advanced Materials **9**

Dual phase steels, high strength low alloy steel, transformation induced plasticity steel, Maraging steel, smart materials, properties and applications of engineering plastics and composites materials-advanced structural ceramics -WC, TiC, TaC, Al2O3, SiC, Si3N4, CBN, and Diamond – Functionally gradient materials, Nano materials.

Unit V: Selection Of Materials And Testing **9**

Motivation, cost basis and service requirements - Selection for mechanical properties, Selection for surface durability - Relationship between materials processing and selection - Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications — Forgeability and castability test-NDT technique

TOTAL: 45 PERIODS

REFERENCES:

1. ASM Handbook Volume02:"Properties and Selection: Nonferrous Alloys and Special-Purpose Materials",ASM international,10th edition,2020.
2. ASMhandbook, volume11, "Failure Analysis and Prevention", ASM international,10th edition, 2002.
3. BurakonsaT.Z.,and Wierzchan.T., "Surface Engineering of Materials"-Principles of Equipment,Techniques,CRCpress,1st edition,2020.
4. CraneF.A.A., CharlesJ.A.,andFurness,J.A.G., "Selection and use of engineering Materials" ,ReedElsevierIndia,2006.
5. CourtneyT.H.,"Mechanical Behaviour of Materials",2nd edition,McGrawHill,2017.
6. DieterG.E.,"Mechanica lMetallurgy",McGrawHilleducation,3rd edition,2017.

CM45A9	Micro and Nano Manufacturing	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce Meso , Micro and Nano manufacturing and their respective applications.
- To familiarize the students with diamond, turn machining.
- To acquaint the students with advanced micro machining and nano finishing methods.
- To familiarize the students with synthesis of nano materials.
- To gain knowledge on the types of characterization techniques to be used.

Course Outcome		Cognitive Skill
CO-01	Explain micro and nano manufacturing methods.	U
CO-02	Extend material deposition methods for manufacturing	A,R
CO-03	Select advanced machining process	U
CO-04	Build nano composite materials.	A
CO-05	Analyze the nano materials and characterization techniques	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	M	L	S	M	M	M	N	M	L
CO-04	M	M	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction: **9**

Introduction to Meso, Micro and Nano manufacturing, Miniaturization and applications, classification-subtractive, additive, micro casting, microforming, micro joining. Micro and Nano products

Unit II: Manufacturing Methods **9**

Material deposition — PVD, CVD, LIGA, Micro stereo lithography, Electro discharge deposition, Traditional micromachining- Theory of micromachining -Chip formation-size effect in micromachining ,micro turning ,micro drilling , micro milling, micro grinding, Diamond turn machining

Unit III: Advanced Machining/ Finishing Processes **9**

Introduction to mechanical and beam energy based micromachining processes- Ultra sonic micromachining, Focused Ion Beam machining, Laser Beam micromachining, Micro/Nano finishing processes- Abrasive Flow Machining, Magnetic Abrasive Finishing, Magneto Rheological Abrasive Flow Machining, Magneto Rheological Finishing. Hybrid micro/nano machining — Electro Chemical Spark Micro Machining, Electro Discharge Grinding, Electrolytic in Process Dressing Grinding

.

Unit IV: Synthesis of Nanomaterials **9**

Introduction to nano materials, Methods of production of Nanoparticles, Sol-gel synthesis, Inert gas condensation, High energy Ball milling, Plasma synthesis, Electro deposition and other techniques. Synthesis of Carbon Nanotubes–Solid carbon source-based production techniques, Gaseous carbon source-based production techniques–Diamond like Carbon coating. Nanowires.

Unit V: Characterization Techniques **9**

Metrology for micro machined components-Optical Microscopy, White Light Interferometry, Molecular Measuring Machine, Micro CMM Scanning Probe Microscopy (SPM) — Scanning Electron Microscope, Transmission Electron Microscope, Scanning Thermal Microscopy, Tribological Characteristics-Micro abrasion wear-Nano indentation-Ellipsometric Analysis

TOTAL: 45 PERIODS

REFERENCES

1. Bandyopadhyay,A.K., "NanoMaterials", New Age International Publishers,NewDelhi,SBN8122422578,2008.
2. Bhushan, B., "Handbookof Nanotechnology",Springer,Germany,ISBN-10:3642025242, 2020.
3. Jain, V.K "Introduction to Micromachining", First edition,Narosa publishing house, ISBN:9781138076426,2017.
4. Jain,V.K, "Micromanufacturing Processes",byCRCPress,ISBN:9781439852903,2012. McGeough,J.A. Micromachining of Engineering Materials,CRCPress,ISBN-10:0824706447,2001

CM45B1	Lean Manufacturing and Six Sigma	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Summarize the basics of Lean and Six Sigma.
- Describe the need and the process of integrating Lean and Six sigma.
- Identify and select the resources required for LSS Projects and selection of projects including Team building.
- Infer the DMAIC process and study the various tools for under taking LSS projects.
- Relate how to institutionalize the LSS efforts.

Course Outcome		Cognitive Skill
CO-01	The students will be able to understand what is Lean and Six sigma the globalized competitive world.	U
CO-02	Students will be able to understand and the importance of integrating Lean and Six sigma and also the process of their integration	A,R
CO-03	The students will be able to plan the Resources required to undertake the LSS projects and also acquire how to select the suitable projects and the teams.	U
CO-04	The students will be able apply DMAIC methodology to execute LSS projects and in this regard, they will be acquainted with various LSS tools	A
CO-05	The students will be able to understand the process of institutionalizing the LSS effort and the Design for LSS.	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	M	S	M	M	M	M	N	M	M
CO-02	M	S	L	M	M	M	N	L	L
CO-03	M	S	S	M	M	M	N	M	L
CO-04	M	S	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction to Lean And Six Sigma: 9

Introduction toLean - Definition, Purpose, Features of Lean; Top seven wastes, Need for Lean management, The philosophy of lean management, Creating a lean enterprise, Elements of Lean, Lean principles, the lean metric, Hidden time traps. Introduction to quality, Definition of six sigma, origin of six sigma, Six sigma concept and Critical success factors for six sigma; Case analysis

Unit II: Integration of Lean And Six Sigma 9

Material deposition — PVD, CVD, LIGA, Micro stereo lithography, Electro discharge deposition, Traditional micromachining- Theory of micromachining -Chip formation-size effect in micromachining ,micro turning ,micro drilling , micro milling, micro grinding, Diamond turn machining

Unit III: Project Selection and Team Building 9

Resource and project selection, Selection of Champions, Identification of potential projects, top down(Balanced score card) and Bottom-up approach — Methods of selecting projects — Benefit/Effort graph, Process mapping, value stream mapping, Predicting and improving team performance, nine team roles and Team leadership; Case study presentations. Black belts, Training of Black belts.

Unit IV: The Dmaic Process and Tools **9**

The DMAIC process ― Toll gate reviews; The DMAIC tools; Define tools ― Project definition form, SIPOC diagram; Measure tools ― Process mapping, Lead time/cycle time, Pareto chart, Cause and Effect matrix, FMEA; Idea–generating and organizing tools– Brainstorming, Nominal group technique, Multi-voting and Cause and effect diagram, Data collection and accuracy tools- Check sheet, Gauge R&R; Understanding and eliminating variation- run charts, control charts and process capability analysis; Analyze tools – Scatterplots, ANOVA, Regression analysis, Time trap analysis; Improve tools ― Mistake proofing, Kaizen, set up time reduction(SMED),TPM,DOE and the pull system.Control tools–statistical process control.

Unit V: Institutionalizing And Design For Lss **9**

Institutionalizing lean six sigma ― improving design velocity, creating cycle time base line, valuing projects, gating the projects, reducing product line complexity, Design for lean six sigma, QFD, Theory of Inventive Problem solving(TRIZ), Robust design; Case study presentations

TOTAL: 45 PERIODS

REFERENCES:

1. James P.Womack,DanielT.Jones, Lean Thinking, Free press business,2003.
2. MichaelL.George,LeanSixSigma,McGraw-Hill.,2002.
3. RonaldG.AskinandJeffreyB.Goldberg ,Design and Analysis of Lean Production Systems, John Wiley&Sons.,2003.
4. Salman Taghizadegan, Essentials of Lean SixSigma,Elsevier,2010

CM45B2	Machine Learning	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the basic aspects of machine learning.
- To get basic knowledge on supervised learning.
- To realize the importance of unsupervised learning.
- To exposed on direct and indirect neuro control schemes.
- To get insight into the basic knowledge on fuzzy logic systems

Course Outcome		Cognitive Skill
CO-01	To get familiarize with the basic aspects of machine learning.	U
CO-02	To get exposure on supervised and unsupervised learning.	A,R
CO-03	To demonstrate the need for neutral networks for modelling and control	U
CO-04	To get familiarize with the fuzzy logic systems.	A
CO-05	To realize the importance of machine learning and its applications	E

R -Remember U - Understand, A-Apply, An - Analyze, E - Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	L	N	M	M
CO-02	S	L	M	M	M	L	N	L	L
CO-03	M	L	M	M	M	L	N	M	L
CO-04	M	L	M	S	M	L	N	M	M
CO-05	M	L	M	S	M	L	N	M	M

S -Strong, M - Medium, L - Low, N - Not relevant

Unit I: Introduction To Machine Learning: 9

Machine learning – Human learning/Machine learning – Types of Machine learning: - Supervised Learning–Unsupervised learning–Reinforcement Learning– Evolutionary Learning - Regression–Classification–The Machine Learning Process:-Data Collection and Preparation –Feature Selection –Algorithm Choice–Parameter and Model Selection–Training–Evaluation

Unit II: Supervised Learning **9**

Linearly separable and nonlinearly separable populations – Introduction to ANN: Biological neuron, artificial neuron, activation function, Perceptron, Multi-Layer Perceptron–Back propagation Learning Algorithm –Radial Basis Function Network–Support Vector Machines: -Kernels–Risk and Loss Functions-Support Vector Machine Algorithm–Multi Class Classification–Support Vector Regression

Unit III: Unsupervised Learning **9**

Introduction – Clustering: -Partitioning Methods: - K-means algorithm - Hierarchical clustering –Fuzzy Clustering – Clustering High-Dimensional Data: - Problems – Challenges – Subspace Clustering –Biclustering – Self Organizing Map(SOM)-SOM algorithm

Unit IV: Neural Networks For Modeling And Control **9**

Need for using ANN in Modeling and Control — Modeling of non-linear systems using ANN: Generation of training data, Identification of Optimal architecture, Model validation — Control of non-linear systems using ANN: Direct and indirect neuro control schemes– Adaptive neurocontroller.

Unit V: Fuzzy Logic Systems **9** Fuzzy set theory — Operation on fuzzy sets: Scalar cardinality, Fuzzy cardinality, Fuzzy union and intersection, Fuzzy complement (Yager and Sugeno), Aggregation, Projection, Composition, Cylindrical extension, Fuzzy relation — Fuzzy membership functions - Modeling of non-linear systems using fuzzymodels: Fuzzification, Knowledgebase, Decision makinglogic, Defuzzification.

TOTAL: 45 PERIODS

REFERENCES:

1. EthemAlpydin,“Introduction to Machine learning(Adaptive Computation and Machine Learning series)” ,MITPress, 2004.
2. Ferdinand van der Heijden, Robert Duin, Dick de Ridder, David M. J. Tax, Classification, Parameter Estimation, and State Estimation: An Engineering
3. Approach Using MATLAB, John Wiley &Sons, 2005.
4. Klir GJ,and Bo,Yuan,“Fuzzysets and fuzzylogic,Theory and applications”,PrenticeHall,1995.

CM45B3	Computer Application in Design	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand fundamental concepts of computer graphics and it's tools in a generic framework
- To impart the parametric fundamentals to create and manipulate geometric models using curves, surfaces and solids.
- To impart the parametric fundamentals to create and manipulate geometric model susing NURBS and solids.
- To provide clear understanding of CAD systemsfor3Dmodeling and viewing.
- To create strong skills of assembly modeling and prepare the student to be an effective user of a standards in CAD system.

Course Outcome – Cos		Cognitive Skill
CO-01	Solve 2D and 3D transformations for the basic entities like line and circle	U
CO-02	Formulate the basic mathematics fundamental to CAD system	A
CO-03	Use the different geometric modeling techniques like feature-based modeling, surface modeling and solid modeling	A, U
CO-04	Create geometric models through animation	A
CO-05	Simulate assembly of parts using Computer-Aided Design software.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Introduction To Computer Graphics Fundamentals 9

Overview of Graphics systems: Video Display Devices, Raster-Scan System, Random Scan Systems, Graphics Monitors and Workstations, Input Devices, Hard Copy Devices, Graphics Software. Output primitives: Line Drawing Algorithm - DDA, Bresenham's and Parallel Line Algorithm. Circle generating algorithm–Midpoint Circle Algorithm. Geometric Transformations: Coordinate Transformations, Windowing and Clipping, 2D Geometric transformations-Translation, Scaling, Shearing, Rotation and Reflection, Composite transformation,3D transformations.

UNIT II:Curves And Surface Modelling 9

Introduction to curves-Analytical curves: line, circle and conics–synthetic curves: Hermitecubicspline-Bezier curve and B-Spline curve–curve manipulations .Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder–synthetic surfaces: Hermitebicubic surface-Bezier surface and B-Spline surface-surface manipulations.

UNIT III: Nurbs And Solid Modeling 9

NURBS-Basics-curves, lines, arcs, circle and bilinear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations – constructive solid Geometry-comparison of representations-user interface for solid modeling.

UNIT IV: Visual Realism 9

Hidden Line removal, Hidden Surface removal,–Hidden Solid Removal algorithms-

Shading–Coloring Animation -Conventional, Computer animation, Engineering animation-types and techniques.

UNIT V: Assembly of Parts and Product Life Cycle Management 9

Assembly modeling — Design for manufacture — Design for assembly — computer aided DFMA –inferences of positions and orientation – tolerances analysis–Center of Gravity and mass property calculations - mechanism simulation. Graphics and computing standards - Data Exchange standards. Product development and management – new product development –models utilized in various phases of new product development–managing product lifecycle.

REFERENCES:

1. Boothroyd,G,"Assembly Automation and Product Design"MarcelDekker,NewYork,1997.
2. ChitaleA.KandGuptaR.C"Product design and manufacturing "PHIlearningprivatelimited, 6thEdition, 2015. DavidRogers,JamesAlanAdams "Mathematical Elements for Computer Graphics "2nd Edition,TataMcGraw-Hilledition.2003.

CM45B4	Research Methodology and IPR	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn the basic aspects of machine learning.
- To get basic knowledge on supervised learning.
- To realize the importance of unsupervised learning.
- To exposed on direct and indirect neuro control schemes.
- To get insight into the basic knowledge on fuzzy logic systems

Course Outcome – Cos		Cognitive Skill
CO-01	Solve 2Dand 3D-transformations for the basic entities like line and circle	U
CO-02	Formulate the basic mathematics fundamental to CAD system	A
CO-03	Use the different geometric modeling techniques like feature based modeling, surface modeling and solid modeling	A, U
CO-04	Create geometric models through animation and transform them into real world systems	A
CO-05	Simulate assembly of parts using Computer-Aided Design software.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: Research Design **9**

Overview of research process and design, Use of Secondary and exploratory data to answer the research question ,Qualitative research, Observation studies, Experiment sand Surveys.

UNIT II: Data Collection And Sources **9**

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data-Preparing,Exploring, examining and displaying.

UNIT III: Data Analysis And Reporting **9**

Overview of Multivariate analysis, Hypotheses testing and Measures of Association, Presenting Insights and findings using written reports and oral presentation.

UNIT IV: Intellectual Property Rights **9**

Intellectual Property— The concept of IPR, Evolution and development of concept of IPR,IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark ,Functions of UNESCO in IPR maintenance.

UNIT V: Patents **9**

Patents — objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process Efilling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses ,Licensing of related patents, patent agents, Registration of patent agents.

TOTAL: 45PERIODS

REFERENCES:

1. CooperDonaldR,SchindlerPamelaSandSharmaJK,"Business Research Methods",TataMcGrawHillEducation,(2012).
2. CatherineJ.Holland,"Intellectual property:Patents,Trademarks,Copyrights,TradeSecrets",EntrepreneurPress,2007.
3. DavidHunt,LongNguyen,MatthewRodgers,"Patent searching:tools&techniques",Wiley,2007.

The Institute of Company Secretaries of India, Statutory body under an Act of parliament," Professional Programme Intellectual Property Rights, Lawand practice", September2013

CM45B5	Industrial Robotics and Expert Systems	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To appreciate the need and scope for robotics and to understand the principles of robot kinematics
- To design the drive systems and its control
- To understand the principles of sensors and vision systems
- To envision the industrial applications of robots and its safety
- To gain knowledge on artificial intelligence and expert systems.

Course Outcome – Cos		Cognitive Skill
CO-01	Understand robot kinematics	U
CO-02	Incorporate mechanical components and concepts in robotics	A
CO-03	Understand the basics of various sensors to effectively design a robot	A
CO-04	Design suitable robots for specific applications	A,U
CO-05	Optimize the robots using Artificial Intelligence	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S-Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	S	L	M	M	N	M	M
CO-02	S	M	S	L	M	M	N	L	L
CO-03	M	L	S	L	M	M	N	M	L
CO-04	M	M	S	L	M	M	N	M	M
CO-05	M	S	S	L	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I:Introduction And Robot Kinematics **9**

Definition need and scope of Industrial robots– Robot anatomy–Work volume– Precision movement – End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics –Methods for orientation and location of objects.

UNIT II:Robot Drives And Control **9**

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

UNIT III:Robot Sensors **9**

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

UNITIV:Robot Cell Design And Application **9**

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

UNITV:Robot Programming, Artificial Intelligence Andexpert Systems **9**

Methods of Robot Programming – Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques–problem representation in AI – Problem reduction and solution techniques – Application of AI and KBES in Robots.

TOTAL: 45PERIODS

REFERENCES:

1. K.S.Fu,Gonzalez,R.C.andLee,C.S.G.,"RoboticsControl,Sensing,Vision and Intelligence",McGrawHill,1987.
2. Koren,Y.,"Robotics for Engineers",McGraw-Hill,1987.
3. Kozyrey,Yu."Industrial Robots", MIRPublishersMoscow,1985.
4. Klafter,R.D.,Chmielewski,T.A.andNegin,M.,"Robotics Engineering– An Integrated Approach" ,Prentice-Hall of IndiaPvt.Ltd.,1984.
5. Deb,S.R."RoboticsTechnologyandFlexibleAutomation",TataMcGraw-Hill,1994
6. Groover,M.P.Weis,M.,Nagel,R.N. and,Odrey,N.G., "Industrial RoboticsTechnology,ProgrammingandApplications",McGraw-Hill,Int.,1986.

   Jordanides,T.andTorby,B.J.,,"ExpertSystemsandRobotics",Springer–Verlag,NewYork,May1991.

CM45B6	Additive Manufacturing	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology
- Gain insights on the need, advantages and limitations of additive manufacturing (AM) versus traditional manufacturing
- Find out the various applications of AM, Deployment levels, Innovative and optimized product design
- To explore the potential of additive manufacturing in different industrial sectors.
- To apply 3D printing technology for additive manufacturing.

Course Outcome – Cos		Cognitive Skill
CO-01	The students are expected to learn about a variety of Additive Manufacturing (AM) technologies.	U
CO-02	Describe additive manufacturing and explain its advantages and disadvantages	A,R
CO-03	Explain the processes used in additive manufacturing for arrange of materials and applications	U
CO-04	Understand the role of additive manufacturing in the design process and their potential to support Design and manufacturing.	A
CO-05	Case studies relevant to mass customized manufacturing, and some of the important research challenges associated with data processing tools	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	L	N	M	M
CO-02	S	M	M	M	M	L	N	L	L
CO-03	M	L	S	M	M	L	N	M	L
CO-04	M	M	S	S	M	L	N	M	M
CO-05	M	L	M	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION **9**

Need-Development of AM systems–AM process chain-Impact of AM on Product Development-Virtual Prototyping- Rapid Tooling–RP to AM-Classification of AM processes-Benefits-Applications.

UNIT II: REVERSE ENGINEERING AND CAD MODELLING **9**

Basic concept-Digitization techniques— Model reconstruction— Data Processing for Rapid Prototyping: CAD model preparation, Data requirements — Geometric modelling techniques: Wireframe, surface and solid modelling — data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation-Software for AM- Case studies.

UNITIII:LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS **9**

Stereo lithography Apparatus (SLA): Principle, pre-build process, part – building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials ,advantages ,limitations and applications.

Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modelling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications-Case studies.

UNIT IV: POWDER BASED ADDITIVE MANUFACTURING SYSTEMS 9

Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS-powder structures, materials, postprocessing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.

UNIT V:OTHER ADDITIVE MANUFACTURING SYSTEMS 9

Three-dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3D Psystems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM),Ballastic Particle Manufacturing (BPM),Selective Laser Melting, Electron Beam Melting.

TOTAL: 45PERIODS

REFERENCES:

1. Chua,C.K.,LeongK.F.andLimC.S.,"Rapidprototyping:Principlesandapplications",secondedition,WorldScientificPublishers,2010.
2. Gebhardt,A.,"Rapidprototyping",HanserGardenerPublications,2003.
3. Gibson,I.,Rosen,D.W.andStucker,B.,"AdditiveManufacturingMethodologies: RapidPrototypingtoDirectDigitalManufacturing",Springer,2010.
4. Hilton,P.D.andJacobs,P.F.,RapidTooling:TechnologiesandIndustrialApplications,CRCpress,2005.

CM45B7	MEMS AND NANO TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To inspire the students to expect to the trends in manufacturing of micro components
- Familiarise the students with various fabrication techniques for micro components.
- Acquaint them with various sensors and actuators
- Introduce them the various methods of developing nano materials
- Make them understand characterization tools

Course Outcome – Cos		Cognitive Skill
CO-01	Realize the need of micro electromechanical systems	U
CO-02	Develop a knowledge to select a sensor for an application	A,R
CO-03	Develop a nano material	U
CO-04	Characterize the Nano material	A
CO-05	Develop an Electromechanical systems	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	M	M	M	L	N	M	M
CO-02	S	S	L	M	M	L	N	L	L
CO-03	M	M	S	M	M	L	N	M	L
CO-04	M	M	S	S	M	L	N	M	M
CO-05	M	M	L	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: OVER VIEW OF MEMS AND MICRO SYSTEMS 9

Definition–historical development–properties, design and fabrication micro-system, micro electronics, working principle, applications and advantages of micro system. Substrates and wafers, silicon as substrate material, mechanical properties of Si, Silicon Compounds - silicon piezoresistors, Gallium arsenide, quartz, polymers for MEMS, conductive polymers.

UNIT II: FABRICATION PROCESSES AND MICRO-SYSTEM PACKAGING 9

Photolithography, photo resist applications, light sources, ion implantation, diffusion– Oxidation –thermal oxidation, silicondioxide, chemical vapour deposition, sputtering-

deposition by epi-taxy–etching — bulk and surface machining — LIGA process — LASER, Electron beam, Ion beam processes – Mask less lithography. Micro system packaging –packaging design– levels of microsystem packaging -die level, device level and system level – interfaces in packaging – packaging technologies-Assembly of Microsystems

UNIT III: MICRODEVICES 9

Sensors – classification – signal conversion ideal characterization of sensors micro actuators, mechanical sensors– measure and - displacement sensors, pressure sensor, flow sensors, Accelerometer, chemical and bio sensor - sensitivity, reliability and response of micro-sensor – micro actuators—applications.

UNIT IV: SCIENCE AND SYNTHESIS OF NANO MATERIALS 9

Classification of nano structures — Effects of nano scale dimensions on various properties — structural, thermal, chemical, magnetic, optical and electronic properties fluid dynamics – Effect of nano scale dimensions on mechanical properties-vibration, bending, fracture-Nanoparticles, Sol-Gel Synthesis, Inert Gas Condensation, High energy Ball Milling, Plasma Synthesis, Electro deposition and other techniques. Synthesis of Carbon nanotubes – Solid carbon source-based production techniques — Gaseous carbon source-based production techniques —Diamond like carbon coating. Top down and bottom-up processes.

UNIT V: CHARACTERIZATION OF NANO MATERIALS 9

Nano-processing systems – Nano measuring systems – characterization – analytical imaging techniques – microscopy techniques, electron microscopy scanning electron microscopy, confocal LASER scanning microscopy - transmission electron microscopy, transmission electron microscopy, scanning tunnelling microscopy, atomic force microscopy, diffraction techniques – spectroscopy techniques – Raman spectroscopy, 3D surface analysis – Mechanical, Magnetic and thermal properties—Nano positioning systems.

TOTAL: 45PERIODS

REFERENCES:

1. Chua,C.K.,LeongK.F.andLimC.S.,"Rapidprototyping:Principlesandapplications ",secondedition,WorldScientificPublishers,2010.
2. Gebhardt,A.,"Rapidprototyping",HanserGardenerPublications,2003.
3. Gibson,I.,Rosen,D.W.andStucker,B.,"AdditiveManufacturingMethodologies:Ra pidPrototypingtoDirectDigitalManufacturing",Springer,2010.
4. Hilton,P.D.andJacobs,P.F.,RapidTooling:TechnologiesandIndustrialApplication s,CRCpress,2005.
5. Kamrani,A.K.andNasr,E.A.,"RapidPrototyping:Theoryandpractice",Springer,2006
6. amrani,A.K.andNasr,E.A.,"RapidPrototyping:Theoryandpractice",Springer,2006

CM45B8	POLYMERS AND COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on various polymer processing techniques
- To learn about various fibre, Matrix materials and their properties
- To learn the methods by which Polymer matrix composites are made
- To study about the composites used for High temperature applications
- To study the behaviour of reinforcements in MMC and PMC.

Course Outcome – Cos		Cognitive Skill
CO-01	To study matrix material, reinforcements of polymer matrix composites, MMC and ceramic matrix composites	U
CO-02	To develop knowledge on processing, interfacial properties and application of composites .	A,R
CO-03	To have ability to develop new fiber or reinforcement materials	U
CO-04	To differentiate between the composites used in room temperature and High temperature applications	A
CO-05	To learn about carbon composites	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	S	L	N	M	M
CO-02	S	M	L	M	S	L	N	L	L
CO-03	S	L	S	M	S	L	N	M	L
CO-04	S	M	S	S	M	L	N	M	M
CO-05	S	L	L	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: PROCESSINGOF POLYMERS 9

Chemistry and Classification of Polymers – Properties of Thermo plastics – Properties of Thermosetting Plastics - Extrusion – Injection Moulding – Blow Moulding – Compression and Transfer Moulding – Casting – Thermo Forming. General Machining properties of Plastics –Machining Parameters and their effect– Joining of Plastics–Thermal bonding–Applications.

UNIT II: FIBERS AND MATRIX MATERIALS 9

Fibers – Fabrication, Structure, properties and applications – Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibres - whiskers– Fabrication of Matrix materials –polymers, metals and ceramics and their properties–interfaces–Wettability–Types of bonding at the interface– Tests for measuring interfacial strength-Physical and chemical properties.

UNIT III: PROCESSING OF POLYMER MATRIX COMPOSITES 9

Thermoset matrix composites: hand layup, spray, filament winding, Pultrusion, resin transfer rmoulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet Moulding Compound — thermoplastic matrix composites — film stacking, diaphragm forming, thermoplastic tape laying, injection moulding – interfaces in PMCs - structure, properties and application of PMCs–recycling of PMCs.

UNIT IV: PROCESSING OF METAL MATRIX COMPOSITES 9

Metallic matrices: aluminium, titanium, magnesium, copper alloys –processing of MMCs: liquid state, Solid state, in situ fabrication techniques – diffusion bonding – powder metallurgy techniques-interfacesinMMCs–mechanical properties–machining of MMCs–Applications.

UNIT V: PROCESSING OF CERAMIC MATRIX COMPOSITES AND CARBON-CARBON COMPOSITES 9

Processing of CMCs: cold pressing, sintering, reaction bonding, liquid infiltration, lanxide process— inset chemical reaction techniques: chemical vapour deposition, chemical vapour impregnation,sol-gel–interfaces inCMCs–mechanical properties and applications of CMCs–Carbon-carbon Composites–applications.

TOTAL: 45PERIODS

REFERENCES:

1. Chua,C.K.,LeongK.F.andLimC.S.,"Rapidprototyping:Principlesandapplications ",secondedition,WorldScientificPublishers,2010.
2. Gebhardt,A.,"Rapidprototyping",HanserGardenerPublications,2003.
3. Gibson,I.,Rosen,D.W.andStucker,B.,"AdditiveManufacturingMethodologies:Ra pidPrototypingtoDirectDigitalManufacturing",Springer,2010.
4. Hilton,P.D.andJacobs,P.F.,RapidTooling:TechnologiesandIndustrialApplication s,CRCpress,2005.
5. Kamrani,A.K.andNasr,E.A.,"RapidPrototyping:Theoryandpractice",Springer,2006
6. amrani,A.K.andNasr,E.A.,"RapidPrototyping:Theoryandpractice",Springer,2006

CM45B9	MATERIAL CHARACTERIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Provide microscopic techniques to analyse crystal structures
- Acquire an understanding on the electron microscopic techniques for characterization
- Gain a fundamental on chemical and thermal analysis
- Provide the knowledge on various static methods to characterize materials
- Study the failure of materials under stress

Course Outcome – Cos		Cognitive Skill
CO-01	To be knowledgeable in microstructure evaluation, crystal structure analysis	U
CO-02	To take images in electron microscopy and process those images,	A,R
CO-03	To do Chemical Thermal Analysis	U
CO-04	Analyze the results of static and dynamic mechanical testing.	A
CO-05	To do mechanical testing	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Program Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	M	M	M	L	N	M	M
CO-02	S	S	L	M	M	L	N	L	L
CO-03	M	M	S	M	M	L	N	M	L
CO-04	M	M	S	S	M	L	N	M	M
CO-05	M	M	L	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: MICRO AND CRYSTAL STRUCTURE ANALYSIS 9

Principles of Optical Microscopy–Specimen Preparation Techniques– Polishing and Etching– Polarization Techniques – Quantitative Metallography – Estimation of grain size – ASTM grain size numbers–Micro structure of Engineering Materials-Elements of Crystallography– X- ray Diffraction – Bragg's law – Techniques of X-ray Crystallography – Debye – Scherercamera – Geiger Diffractometer – analysis of Diffraction patterns – Inter planer spacing –Identification of Crystal Structure, Elements of Electron Diffraction.

UNIT II: ELECTRON MICROSCOPY 9

Interaction of Electron Beam with Materials Transmission ElectronMicroscopy-Specimen Preparation — Imaging Techniques — BF & DF — SAD — Electron Probe Microanalysis —Scanning Electron Microscopy — Construction & working of SEM — various Imaging Techniques – Applications- Atomic Force Microscopy-Construction & working of AFM -Applications.

UNIT III: CHEMICAL AND THERMAL ANALYSIS 9

Basic Principles, Practice and Applications of X-Ray Spectrometry, Wave Dispersive X-RaySpectrometry, Auger Spectroscopy, Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Proton Induced X-Ray Emission Spectroscopy, Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) And Thermo Gravitymetric Analysis(TGA)

UNIT IV: MECHANICAL TESTING–STATICTESTS 9

Hardness – Brinell, Vickers, Rockwell and Micro Hardness Test – Tensile Test – Stress –Strain plot – Proof Stress – Torsion Test - Ductility Measurement – Impact Test – Charpy &Izod – DWTT - Fracture Toughness Test, Codes and standards for testing metallic and composite materials.

UNIT V: MECHANICAL TESTING–DYNAMIC TESTS 9

Fatigue–Low& High Cycle Fatigues–Rotating Beam& Plate Bending HCF tests– S-N curve – LCF tests – Crack Growth studies – Creep Tests – LM parameters – AE Tests-modal analysis-Applications of Dynamic Tests.

TOTAL: 45PERIODS

REFERENCES:

1. Chua,C.K.,LeongK.F.andLimC.S.,"Rapidprototyping:Principlesandapplications",secondedition,WorldScientificPublishers,2010.
2. Gebhardt,A.,"Rapidprototyping",HanserGardenerPublications,2003.
3. Gibson,I.,Rosen,D.W.andStucker,B.,"AdditiveManufacturingMethodologies:RapidPrototypingtoDirectDigitalManufacturing",Springer,2010.
4. Hilton,P.D.andJacobs,P.F.,RapidTooling:TechnologiesandIndustrialApplications,CRCpress,2005.
5. Kamrani,A.K.andNasr,E.A.,"RapidPrototyping:Theoryandpractice",Springer,2006
6. amrani,A.K.andNasr,E.A.,"RapidPrototyping:Theoryandpractice",Springer,2006

CM45C1	MANUFACTURING SYSTEM SIMULATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To discuss the importance and advantages of applying simulation and modelling techniques
- To teach various random number generation techniques, its use in simulation
- To explain the applications of random probability distributions in real time environments.
- To train students to solve discrete event problems using software.
- To train students on Simulation models using a simulation software.

Course Outcome – Cos		Cognitive Skill
CO-01	Explain the Manufacturing Models of Discrete event systems	A
CO-02	Develop the Uncertainty using Random numbers and Random Variates	A,E
CO-03	Analyze the verification & valediction of Models and Optimization	A
CO-04	Demonstrate the concepts of modeling layers of society's critical infrastructure networks	A,An
CO-05	Make use of tools to view and control simulations	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Systems and its types, Types of Modelling, Principles used in Modeling, simulation as a decision making tool, types of simulation, Advantages and disadvantages of simulation, Steps in simulation model building - statistical models in simulation -discrete and continuous system

UNIT II: RANDOM NUMBERS 9

Random number generation -Properties of Random Numbers –Generation of Pseudo Random Numbers – Techniques –Tests for Random Numbers

UNIT III: RANDOM VARIATES 9

Random variate generation-Inverse Transform Technique –Direct Transform Techniques Convolution Method Acceptance Rejection Technique– Routines for Random Variate Generation, Testing -Analysis of simulation data.

UNIT IV: ANALYSIS OF SIMULATION DATA 9

Input modelling-Fitness tests – verification and validation of simulation models – output analysis for a single model, Comparison and evaluation of alternate system design, Optimization using simulation.

UNIT V: SIMULATION LANGUAGES AND CASE STUDIES 9

Simulation languages and packages-Case studies in WITNESS; FLEXSIM, ARENA, SIMQUICK- Simulation based optimization-Modelling and Simulation with Petrinets -Case studies in manufacturing and material handling system- Monte Carlo Simulation. Simulation of

Single Server Queuing System. Simulation of manufacturing shop Simulation of Inventory System

TOTAL: 45 PERIODS

REFERENCES:

1. Geoffrey Gordon, "System Simulation", 2nd Edition, Prentice Hall, India, 2020.

2. Jerry Banks & John S.Carson, Barry L Nelson, “Discrete event system simulation”, Prentice Hall,2000.

3. Law A.M, “Simulation Modelling and Analysis”,Fifth edition, Tata Mc Graw Hill,2014.

4. NarsinghDeo, “System Simulation with Digital Computer”,Fith edition, Prentice Hall,2014.

5. Pidd, M, “Computer Simulation in Management Science”, Fifth edition,John Wiley & Sons, Inc,2016.

CM45C2	DATA ANALYTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- Recognize the importance of data analytics
- Exhibit competence on data analytics packages
- Apply solution methodologies for industrial problems.

COURSE OUTCOMES:

On completion of the course, the student will be able to:

Course Outcome – Cos		Cognitive Skill
CO-01	To recognize the importance of data analytics	A
CO-02	To Exhibit competence on data analytics packages	A,E
CO-03	To apply solution methodologies for industrial problems.	A
CO-04	To recognize the importance of Factor Analysis	A, An
CO-05	To recognize the importance of Latent Variable Models	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Introduction to Multivariate Statistics-Degree of Relationship among Variables-Review of Univariate and Bivariate Statistics-Screening Data Prior to Analysis-Missing Data, Outliers, Normality, Linearity, and Homoscedasticity.

UNIT II: MULTIPLE REGRESSION 9

Multiple Regression- Linear and Nonlinear techniques- Backward-Forward-Stepwise Hierarchical regression-Testing interactions (2way interaction) - Analysis of Variance and Covariance (ANOVA & ANCOVA) - Multivariate Analysis of Variance and Covariance (MANOVA & MANCOVA).

UNIT III: LOGISTIC REGRESSION 9

Regression with binary dependent variable -Simple Discriminant Analysis Multiple Discriminant analysis-Assessing classification accuracy- Conjoint analysis (Full profile method).

UNIT IV: PRINCIPAL COMPONENT ANALYSIS 9

Principal Component Analysis -Factor Analysis- Orthogonal and Oblique Rotation-Factor Score Estimation-Multidimensional Scaling-Perceptual Map-Cluster Analysis (Hierarchical Vs Nonhierarchical Clustering).

UNIT V: Latent Variable Models 9

Latent Variable Models an Introduction to Factor, Path, and Structural Equation Analysis- Time series data analysis (ARIMA model) – Decision tree analysis (CHAID, CART) - Introduction to Big Data Management.

TOTAL:45PERIODS

REFERENCES:

1. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. "Multivariate data analysis", (7th edition). Pearson India. 2015
2. Tabachnick, B. G., &Fidell, L. S., "Using multivariate statistics", (5th edition). Pearson Prentice Hall, 2001
3. Gujarati, D. N. , "Basic econometrics", Tata McGraw-Hill Education, 2012
4. Malhotra, N. K., " Marketing research: An applied orientation", 5/e. Pearson Education India, 2008
5. Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. " Applied multiple regression/correlation analysis for the behavioral sciences", Routledge., 2013
6. Han, J., Kamber, M., & Pei, J. "Data mining: concepts and techniques: concepts and techniques", Elsevier, 2011.

CM45C3	INTERNET OF THINGS FOR MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To understand the basics of IoT, Opportunities and challenges in IoT
- To design a IoT solution
- To develop an IoT protype
- To explain the various protocols used in IoT and Localization
- To examine the applications of IoT in Manufacturing.

OUTCOMES:

On completion of the course, the students will be able to

Course Outcome – Cos		Cognitive Skill
CO-01	Identify the Opportunities and challenges in IoT	A
CO-02	Propose a suitable IoT design	A,E
CO-03	Develop an optimized IoT protype	E
CO-04	Understand the various protocols used in IoT and Localization	U
CO-05	Understand the applications of IoT in Manufacturing	U,A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	M	M	M	M	L	N	M	M
CO-02	M	S	L	M	M	L	N	L	L
CO-03	M	S	L	M	M	L	N	L	L
CO-04	M	S	L	M	M	L	N	L	L
CO-05	M	S	L	M	M	L	N	L	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Technology of the IoT and applications, IoT data management requirements, Architecture of IoT, Security issues Opportunities for IoT -Issues in implementing IoT. Technological challenges, RFID and the Electronic Product Code (EPC) network, the web of things.

UNIT II: DESIGN OF IoT 9

Design challenges in IoT -Standardization, Security and privacy, Infrastructure, Analytics. Design steps for implementing IoT.

UNIT III: PROTOTYPING OF IoT 9

Design principles for connected devices -Embedded devices, physical design, online components, embedded coding system. Informed Manufacturing plant – Elements, IoT implementation in Transportation and logistics, Energy and utilities, Automotive Connected supply chain, Plant floor control automation, remote monitoring, Management of critical assets, Energy management and resource optimization, proactive maintenance.

UNIT IV: PREREQUISITES FOR IoT 9

IOT Technologies Wireless protocols low-power design (Bluetooth Low Energy), range extension techniques (data mining and mesh networking), and data-intensive IoT for continuous recognition applications Data storage and analysis Localization algorithms Localization for mobile systems

UNIT V: APPLICATION IN MANUFACTURING 9

Applications HCI and IoT world - Multilingual interactions Robotics and Autonomous Vehicles Sensing and data processing-Simultaneous mapping and localization-Levels of autonomy, Smart factories, Future research challenges

TOTAL : 45 PERIODS

REFERENCES:

1. 1.Adrian McEwan and Hakim Cassimally, "Designing the internet of things", Wiley, 2013.
2. 2.Code Halos: How the Digital Lives of People, Things, and Organizations are Changing the Rules of Business, by Malcolm Frank, Paul Roehrig and Ben Pring, published by John Wiley & Sons.
3. 3.Internet of Things: A Hands-On Approach by Vijay Madisetti, Arshdeep Bahga, VPT; 1st edition 2014.
4. 4.Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine-to-Machine to the Internet of Things - Introduction to a New Age of Intelligence" Elsevier 2020.
5. 5.Meta Products -Building the Internet of Things by WimerHazenberg, Menno Huisman, BIS Publishers 2014.

CM45C4	WAREHOUSE LAYOUT PLANNING AND PART FEEDING METHODS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on various layout planning methods
- To get familiarized with various racking systems
- To gain an insight on material handling systems
- To learn various part feeding methods, optimum design of feeding routes and feeding methods
- To develop knowledge on warehouse management systems, safety requirements of ware house panning.

Course Outcome – Cos		Cognitive Skill
CO-01	Apply the Design and plan warehouse layouts	U,A
CO-02	Explain the Plan racking systems	A,R
CO-03	Make use of material handling systems for warehouse requirements.	U,A
CO-04	To take advantage of various part feeding mechanisms	A
CO-05	Develop knowledge on warehouse management systems and identify the safety requirements of warehouse panning.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: LAYOUT PLANNING: 8

Layout Planning - Importance of Layout Planning - General Steps in Layout and Space Requirements Planning - Warehouse Activities - Determining Space Requirements – Develop realistic and Ideal Layout for Storage and Retrieval – Material storage methods for each part

UNIT II: RACKING SYSTEMS FOR WAREHOUSE: 9

Selection of Ware House Equipments and Material Handling Systems - Racking and Shelving Systems - Rack Planning Considerations - General Categories of Rack Systems - Large Products Storage System

- Pallet Storage Systems Selection - Selection of Racking Systems - Technical Specification of the High Rack System - Design Standard for Racking Systems - Layout of High Rack Storage - Warehouse Floors - Industrial Floorings - Floor Loading and Preparation – Calculations.

UNIT III: MATERIAL HANDLING SYSTEMS FOR WAREHOUSE 9

Material Handling System - Material Flow Path - Selection Criteria to Determine Equipment - Material Handling Equipment Classification – MHE Manufacturer's Worldwide Ranking - Comparison of Fork Lift, Reach Truck and Narrow Aisle Truck - MHE Service and Battery Charging - Crane Design Requirements

UNIT IV: PART FEEDING: 10

Part feeding - Number of Tow Truck Requirements - Calculations - Kitting Trolley Route Map - Kitting Time Estimation - Kitting Trolley Feeding Man Power Calculation - Kitting Trolley Design Methodology - Assumptions in Kitting Design - Kit Trolley Design - Key Ware House Planning- Issues to be Considered during Ware Housing Planning - Check List for Warehouse Layout Planning - Return on Assets

UNIT V: WAREHOUSE MANAGEMENT SYSTEMS, SAFETY AND STAFFING 9

WMS Support in Ware House Management - Benefits of a WMS - Components of a WMS - WMS Data

- WMS Functions - WMS Reports - Ware House Safety Requirements, Warehouse Staffing - Personnel Requirements for a Typical Warehouse.

TOTAL: 45 PERIODS

REFERENCES:

1. 1.Bartholdi, J.J. and Hackman, S.T., "Warehouse & Distribution science", Release 0.89, The Supply chain and logistics Institute, School of Industrial and systems Engineering, Georgia Institute of technology, Atlanta, GA 30332-0205 USA, Revised August 20, 2008.
2. 2.Frazelle, E.H.,"World-Class warehousing and Material handling", TATA McGraw-Hill Edition 2004.
3. 3.Hanson, R., "In-plant materials supply: Supporting the choice between kitting and continuous supply", Department of Technology Management and Economics, Chalmers University of Technology, Gothenburg, Sweden 2012.
4. (http://publications.lib.chalmers.se/records/fulltext/155418.pdf)
5. 4.IS 1893(Part 1): 2002, Indian Standard, Criteria For Earthquake Resistant Design Of Structures, Part 1 General provisions and buildings, (Fifth Revision).
6. 5.Richards, G., "Warehouse Management: A complete guide to improving efficiency and minimizing costs in the modern warehouse", London Philadelphia, 2011.
7. 6.Tompkins, J.A., and Smith, J.D., "The Warehouse Management Handbook", Tompkins press, 2002.

CM45C5	TOTAL QUALITY SYSTEMS AND ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To gain an insight on Totally quality systems
- To get familiarized with various quality audit systems
- To get acquainted with elements of TQM
- To appreciate implementation of quality by design concepts
- To get acquainted with the laws that governs the product quality and safety.

Course Outcome – Cos		Cognitive Skill
CO-01	Assess the Totally quality system concepts	An
CO-02	Recognize various quality audit systems	A,U
CO-03	Evaluate various elements of TQM	E
CO-04	Implement the quality by design concepts	A
CO-05	Recognize the laws that governs the product quality and safety	E,R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Definition of Quality and TQM - Importance of quality - Principles of Quality Management - Pioneers of TQM - Quality costs - Customer Orientation - Benchmarking - Re-engineering - Concurrent Engineering.

UNIT II: PRACTICES OF TQM 9

Quality system - ISO 9001:2000 - QS 9000, ISO 14000 - Quality Auditing - Leadership - Organisational Structure - Team Building - Information Systems and Documentation.

UNIT III: TECHNIQUES OF TQM 9

Single Vendor Concept - JIT - Quality Function deployment - Quality Circles - KAIZEN - SGA - POKA YOKE - Taguchi Methods.

UNIT IV: QUALITY BY DESIGN 9

Introduction – Rationale for implementation – Benefits– Teams – Communication models – Implementation – Tools – Misconceptions and Pitfalls.

UNIT V: PRODUCTS LIABILITY 9

Introduction – Product safety law – products liability law – defenses – Proof and the expert witness – Financial Loss – The future of products liability – Prevention.

TOTAL: 45 PERIODS

REFERENCES:

1. 1.Baird, C.W., “The Six Sigma Manual for Small and Medium Businesses”, Atlantic Publishing Company (FL), Reprint 2011.
2. 2.Bank, J., " The Essence of Total Quality Management ", Prentice Hall of India Pvt.Ltd., 2005.
3. 3.Besterfield, D.H., Besterfield, C.M, Besterfield, G.H. and Besterfield, M.S., “Total Quality Management ", Pearson Education, 2002.
4. 4.Dalela, S. and Saurabh, “ISO 9000 A Manual for Total Quality Management ", S.Chand and Company Ltd., 2008.
5. 5.Noori, H. and Radford,R., " Production and Operations management - Total Quality and Responsiveness ", McGraw-Hill Inc, 2010.
6. 6.Zairi, M., “Total Quality Management for Engineers ", Woodhead Publishing Limited 2011.

CM45C6	TOOL ENGINEERING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the various materials and tools for production of components.
- To impart knowledge in design of various cutting tools and its nomenclature.
- To familiarize in designing dies for various processes.
- To understand the design of differenent jigs and fixtures
- To be acquainted with various gauges and tool design for CNC machines.

Course Outcome – Cos		Cognitive Skill
CO-01	Apply domain knowledge will increase their employability skills	A
CO-02	Make use of this knowledge to develop innovative ideas work holding methods	U,R
CO-03	Explain the encourages to involve in research in the area of machining	A
CO-04	Improve the design of jigs and fixtures	A
CO-05	Identify the measuring gauges	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Broad Classification of Tools-Cutting tools, Dies, Holding and Measuring tools, Tool materials and heat treatment- Ferrous, Non-ferrous and Non metallic materials, tool making practices.

UNIT II: DESIGN OF CUTTING TOOLS 9

Single Point Cutting Tools: Classification, Nomenclature, geometry, design of single point tools for lathes, shapers, planers etc. Chip breakers and their design. Multipoint Cutting Tools: Classification and specification, nomenclature, Design of drills, milling cutters, broaches, taps etc. Design of Form Tools: Flat and circular form tools, their design and applications.

UNIT III: DESIGN OF DIES 9

Classification of dies, Design of Dies for Bulk metal Deformation-Wire Drawing, Extrusion, Forging and Rolling; Design of Dies for Sheet metal: Blanking and Piercing, Bending and Deep-drawing; Design of Dies used for Casting and Moulding, Powder Metallurgy die design.

UNIT IV: DESIGN OF JIGS AND FIXTURES 9

Classification of Jigs and Fixtures, Fundamental Principles of design of Jigs and Fixtures, Location and Clamping in Jigs and fixtures, Simple design for drilling Jigs, Milling fixtures etc. Indexing Jigs and fixtures.

UNIT V: DESIGN OF LIMIT GAUGES AND TOOL DESIGN FOR CNC MACHINES 9

Fixed gauges, gauge tolerances, indicating gauges, automatic gauges, selection of materials, tool design for CNC machines- fixture design, cutting tools, tool holding, tool pre-setter, automatic tool changers and positioners.

TOTAL: 45 PERIODS

REFERENCES:

1. Donaldson, C., “Tool Design”, Tata Mc-Graw Hill, 2006.
2. Grant, H,E., “Jigs and Fixtures, Tata Mc-Graw Hill, 2006.
3. Joshi, P.H., “Jigs and Fixtures, Tata Mc-Graw Hill, 2003.
4. Kempster, M.H.A., “Principles of Jig and Tool Design”, English University Press Ltd.,2012.
5. Pollack, H.W., “Tool Design” Reston Publishing Company, Inc. 2015.

CM45C7	GREEN MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To expose the students to the basics of environmental sustainability and impact assessment objectives.

- To incorporate knowledge about the environmental based improvements towards lean manufacturing systems.
- To analyze various machineries with intent to conserve energy
- To analyze hazardous and solid wastes with intent to point out areas of adverse environmental impact and how this impact could be minimized or prevented.
- To impart the knowledge about the need, procedure and benefits of Green-Co rating.

Course Outcome – Cos		**Cognitive Skill**
CO-01	Understand the Concepts of environmental sustainability and environmental impact assessment objectives	U
CO-02	Apply suitable schemes towards design of green manufacturing requirements.	A,R
CO-03	Analyze manufacturing processes towards conservation of energy.	U,An
CO-04	Analyze manufacturing processes towards minimization or prevention of hazardous and solid wastes.	A
CO-05	Acquire Knowledge of green co-rating and its benefits are well known to the students.	U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	**PO-A**	**PO-B**	**PO-C**	**PO-D**	**PO-E**	**PO-F**	**PO-G**	**PO-H**	**PO-I**
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT – I ENVIRONMENTAL SUSTAINABILITY AND IMPACT ASSESSMENT **9**

Environmental impact assessment objectives – Legislative development – European community directive – Hungarian directive. Strategic environmental assessment and sustainability appraisal. Regional spatial planning and environmental policy.

UNIT – II LEAN MANUFACTURING AND GREEN ENERGY SYSTEM **9**

Conventional Manufacturing versus Lean Manufacturing – Principles of Lean Manufacturing. World energy consumption – Greenhouse effect, Global warming. Energy conservation and measurement principles with their applicability in engineering and process industries.

UNIT – III ENERGY SAVING MACHINERY AND COMPONENTS **9**

Electricity Billing: Components and Costs – kVA – Need and Control – Determination of kVA demand and Consumption. Selection of fans, pumps and Compressors – Performance Evaluation – Cause for inefficient operation – scope for energy conservation.

UNIT – IV HAZARDOUS AND SOLID WASTE MANAGEMENT **9**

Hazardous waste: definition, terminology, classification and Sources – Need for hazardous waste management: Need, Handling, methods of collection, storage and transport with suitable examples. Solid waste management: Need, Waste prevention and Life cycle assessment. Collection, storage, reuse and recycling of solid waste with suitable examples.

UNIT – V GREEN CO-RATING **9**

Ecological Footprint - Need for Green Co-Rating – Green Co-Rating System – Intent – System Approach – Weightage- Assessment Process – Types of Rating – Green Co-Benefits – Case,Studies of Green Co-Rating.

TOTAL: 45 PERIODS

REFERENCES:

1. Dornfield David, Green Manufacturing, Springer, 2013.
2. Davim J Paulo, Green Manufacturing Processes and Systems, Springer, 2013.
3. Cairncrss and Francis – Costing the earth – Harvard Business School Press – 2009.
4. World Commission on Environment and Development (WCED), Our Common Future, Oxford
5. University Press 2005.
6. Green Co Case Study Booklet, CII – Sohrabji Godrej Green Business Centre, 2015.

CM45C8	SENSORS FOR MANUFACTURING AND CONDITION MONITORING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make students familiar with various sensors in manufacturing and signal processing.
- To impart knowledge on sensors used in workpiece monitoring.
- To explain various sensors used in machine tool monitoring.
- To learn various sensors used in machining process monitoring.
- To brief the advanced and smart sensor technologies.

Course Outcome – Cos		Cognitive Skill
CO-01	Recognize the importance of sensors and condition monitoring in manufacturing.	R
CO-02	Identify suitable sensors for monitoring workpiece during machining operation.	A,R
CO-03	Identify suitable sensors for monitoring machine tool during machining operation.	A,R
CO-04	Identify suitable sensors in monitoring the machining process.	A
CO-05	Perceive the usage and importance of advanced sensors in manufacturing industries.	E,U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	L	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	S	L	L	M	M	M	N	M	M
CO-04	S	L	L	M	M	M	N	M	M
CO-05	S	L	L	M	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO SENSORS 9

Role of sensors in manufacturing and condition monitoring – Principles – Classification Applications – Basic requirements of sensor – Signal processing and decision making.

UNIT II: SENSORS FOR WORKPIECE MONITORING 9

Mechanical, Electrical, Electro-mechanical, Opto-electrical, Optical, Pneumatic, Capacitance, Eddy- current and Magnetic sensors.

UNIT III: SENSORS FOR MACHINE TOOL MONITORING 9

Position measurements: Linear, angular and velocity sensors – Calibration of machine tools – Collision detection measurements.

UNIT IV: SENSORS FOR MACHINING PROCESSES 9

Sensors for condition monitoring: Force, torque, power, temperature, vibration, acoustic emission, tool sensors, chip control sensors – Adaptive control system – Intelligent systems for machining processes.

UNIT V: ADVANCED SENSORS 9

Optical and machine vision sensors – Smart/Intelligent sensors – Integrated sensors – Robot sensors – Micro-sensors – Nano-sensors.

TOTAL: 45 PERIODS

REFERENCES:

1. 1.Considine, D.M. and Glenn, D., "Standard Handbook of Industrial Automation: Advanced Industrial Technology 01", Chapman and Hall, New York, DOI: 10.1017/S0263574700004392, 2000.
2. 2.Sinclair, I.R., "Sensors and Transducers" Elsevier India Private Limited, New Delhi, India, ISBN: 978-0-7506-4932-1, 2001.
3. 3.Tönshoff, H.K. and Inasaki, I., "Sensors in Manufacturing: Sensors Applications-Volume1", Wiley- VCH Verlag GmbH, Weinheim, ISBNs: 3-527-29558-5 (Hardcover); 3-527-60002-7 (Electronic), 2001.
4. 4.Venkatesh, V.C. and Chandrasekaran, H., "Experimental Techniques in Metal Cutting", Prentice- Hall of India Private Limited, New Delhi, India, ISBN: 0-87692-449-6, 2015.
5. 5.Wang, L. and Gao, R.X., "Condition Monitoring and Control for Intelligent Manufacturing", Springer- Verlog London Limited, ISBN-13:978-1-84628-263-3, 2006.

CM45C9	RELIABILITY AND TOTAL PRODUCTIVE MAINTENANCE	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To gain an insight on Reliability function and life time calculations relevant to maintenance
- To get familiarized with various failure data analysis methods
- To be acquainted with various reliability prediction methods
- To get accustomed with reliability estimation techniques
- To understand the concepts of Total Productive Maintenance

Course Outcome – Cos		Cognitive Skill
CO-01	To incorporate knowledge about the Reliability function and life time calculations relevant to maintenance	U
CO-02	To incorporate knowledge about the various failure data analysis methods	U,R
CO-03	To incorporate knowledge about the various reliability prediction methods	U
CO-04	Perceive the importance of Total Productive Maintenance	U
CO-05	Perceive the importance of reliability estimation techniques	R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I : INTRODUCTION 9

Reliability function - MTBF - MTTF - mortality curve - availability -Maintainability.

UNIT II: FAILURE DATA ANALYSIS 9

Repair time distributions - exponential, normal, log normal, gamma, and Weibull - reliability data requirements - Graphical evaluation.

UNIT III: RELIABILITY PREDICTION 9

Failure rate estimates - Effect of environment and stress - Series and Parallel systems - RDB analysis – Standby Systems - Complex Systems.

UNIT IV: RELIABILITY MANAGEMENT 9

Reliability demonstration testing - Reliability growth testing - Duane curve -Risk assessment - FMEA, Fault tree.

UNIT V: TOTAL PRODUCTIVE MAINTENANCE 9

Causes of Machine Failures - Downtime - Maintenance policies - Restorability predictions - Replacement models - Spares provisioning -Maintenance management – Total Productive Maintenance – Maximizing equipment effectiveness – Organizing for TPM implementation – Implementation – TPM small group activities.

TOTAL: 45 PERIODS

REFERENCES:

1. Birolini, A., “Reliability Engineering: Theory and Practice”,2nd edition, Springer, 2013.
2. Gopalakrishnan. P., and Banerji, A.K., “Maintenance and Spare Parts Management ", Prentice Hall of India, New Delhi, 2000.
3. Kales, P., “Reliability for technology Engineering and Management ", Prentice Hall, New Jersey, 2005.
4. Modarres,M., "Reliability and Risk Analysis ", Meral Dekker Inc., 2016.
5. Nakajima, S., “Introduction to TPM”, Productivity Press, 2018.

CM45D1	PROJECT MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Compare various models used in project selection. Define project planning, and estimate the cost involved.
- Apply network techniques for project scheduling and resource allocation.
- Summarize the information needed planning, monitoring and controlling cycle of a project. Recognize the values of project audit.

Course Outcome – Cos		Cognitive Skill
CO-01	Understand various models used in project selection.	U
CO-02	Acquire knowledge in project planning, and estimate the cost involved.	A,R
CO-03	Prepare Project Scheduling and resource allocation.	An
CO-04	Understand about planning, monitoring and controlling cycle of a project.	U
CO-05	Understand the values of project audit.	U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	M	S	S	S	L	M	L
CO-02	M	M	M	S	S	M	L	M	L
CO-03	L	S	M	S	S	S	L	M	L
CO-04	L	S	M	S	S	S	L	M	L
CO-05	M	M	M	S	S	M	L	M	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: STRATEGIC MANAGEMENT AND PROJECT SELECTION 9

Project selection models, Project portfolio process, Analysis under uncertainty, Project organization, Matrix organization

UNIT II: PROJECT PLANNING AND COST ESTIMATION 9

Work breakdown structure, Systems integration, Interface coordination, Project life cycle, Conflict and negotiation, Estimating Project Budgets, Process of cost estimation.

UNIT III: PROJECT IMPLEMENTATION 9

Scheduling: Network Techniques PERT and CPM, Risk analysis using simulation, CPM- crashing a project, Resource loading, leveling, and allocation.

UNIT IV: MONITORING AND INFORMATION SYSTEMS 9

Information needs and the reporting process, computerized PMIS, Earned value analysis, Planning- Monitoring-Controlling cycle, Project control: types of control processes, design of control systems, control of change and scope

UNIT V: PROJECT AUDITING 9

Construction and use of audit report, Project audit life cycle, Essentials of audit and evaluation, Varieties of project termination, the termination process, The Final Report – A project history

TOTAL: 45 PERIODS

REFERENCES:

1. Harold Kerzner, Project Management – A Systems Approach to Planning, Scheduling and Controlling, John Wiley and Sons, 12th edition, 2017.
2. Jack R. Meredith, and Samuel J. Mantel Jr, Project Management – A Managerial Approach, John Wiley and Sons, 10th edition, 2017.
3. Panneerselvam .R, Senthil Kumar .P, Project Management, PHI, 2009.

CM45D2	ADVANCED MACHINE TOOL DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Selecting the different machine tool mechanisms.
- Designing the Multi speed Gear Box and feed drives.
- Designing the machine tool structures.
- Designing the guideways and power screws.
- Designing the spindles and bearings.

Course Outcome – Cos		Cognitive Skill
CO-01	Select the different machine tool mechanisms.	A
CO-02	Design the Multi speed Gear Box and feed drives.	A,R
CO-03	Design the machine tool structures.	A
CO-04	Design the guideways and power screws.	A
CO-05	Design the spindles and bearings.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	M	L	S	M	M	M	N	M	L
CO-04	M	M	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO MACHINE TOOL DESIGN 9

Introduction to Machine Tool Drives and Mechanisms, Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission

UNIT II: REGULATION OF SPEEDS AND FEEDS 9

Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design

UNIT III: DESIGN OF MACHINE TOOL STRUCTURES 9

Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool Structures, Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriage.

UNIT IV: DESIGN OF GUIDEWAYS AND POWER SCREWS 9

Functions and Types of Guideways, Design of Guideways, Design of Aerostatic Slide ways, Design of Anti-Friction Guideways, Combination Guideways, Design of Power Screws.

UNIT V: DESIGN OF SPINDLES AND SPINDLE SUPPORT 9

Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings. Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness

TOTAL = 45 PERIODS

REFERENCES:

1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 3rd edition 2012.
2. G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, 2015.
3. K Pal, S. K. Basu, "Design of Machine Tools", 6th Edition. Oxford IBH, 2014.
4. N. S. Acherkhan, "Machine Tool Design", Volume 2 University Press of the Pacific, 2000.
5. F. Koenigsberger, Design Principles of Metal-Cutting Machine Tools, Pergamon Press, 2000.

CM45D3	MANAGEMENT OF MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To teach the different aspects of manufacturing and competitiveness
- To Identify the flow design for products
- To make the students Select job design and work measurement
- Train the students to evaluate MRP systems and inventory model
- To create ability to apply reengineering concepts in manufacturing

Course Outcome – Cos		Cognitive Skill
CO-01	Able to Classify the different aspects of manufacturing	An
CO-02	Able to Identify the flow design for products	A,R
CO-03	Ability to Evaluate MRP systems and inventory model	E
CO-04	Capacity to Select job design and work measurement	A
CO-05	Know the procedure to apply reengineering concepts in manufacturing	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	M	S	M	M	M	M	N	M	M
CO-02	M	S	L	M	M	M	N	L	L
CO-03	M	S	S	M	M	M	N	M	L
CO-04	M	S	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I : INTRODUCTION: 6

Elements – ManufacturingStrategies and competitiveness-Meeting the competitive Project management.

UNIT II: DESIGNING OF PRODUCTS 9

Process selection-Process flow Design – Operations Technology -Waiting line management-Computer simulation of waiting lines – Quality management.

UNIT III: DESIGN OF FACILITIES AND JOBS 10

Capacity planning – Strategies – Planning service capacity - JIT – Facility location and layout - Job Design and Work measurement.

UNIT IV: INVENTORY SYSTEMS AND MRP 10

Definition-Purposes of Inventory-Inventory models-Fixed order Quantity models and Fixed-time period models. MRP Systems-MRP system structures- Improvements for MRP system-Advanced MRP-type systems

UNIT V: REVISING THE SYSTEM 10

Operations consulting – BPR - Synchronous Manufacturing and theory of Constraints.

TOTAL: 45 PERIODS

REFERENCES:

1. Chary, S.N., "Production and Operations Management", Tata McGraw-Hill, 5th Edition 2017.
2. Chase, Aquilano and Jacobs, "Production and Operations Management", 4th Edition, Tata McGraw Hill, 2010.
1. Jay, H. and Render, B.,"Production and Operations Management: Strategic and Tactical Decisions", Business & Economics – 2006.
3. Operations Management, Jae K. Shim, Joel G. Siegel - Business & Economics, 2011.
4. Robert, A.O., "Manufacturing management: a quantitative approach", International Textbook Co, 2012.

CM45D4	DESIGN OF FLUID POWER SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVE:

- To explain the principles of Hydraulic actuation systems and valves
- To learn hydraulic circuits suitable for different applications
- To get exposure on principles of Pneumatic systems and Pneumatic circuits
- To learn various designing methods of Pneumatic circuits
- To understand the applications of computer control in fluid power

Course Outcome – Cos		Cognitive Skill
CO-01	Demonstrate various Hydraulic actuation systems and valves	E
CO-02	Design and analyse hydraulic circuits	A,R
CO-03	Design and analyse pneumatic circuits	U,A
CO-04	Choose a suitable designing method for a pneumatic circuit	A
CO-05	Apply fuzzy logic in fluid power and to identify suitable maintenance methods	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	L	N	M	M
CO-02	S	L	M	M	M	L	N	L	L
CO-03	M	L	M	M	M	L	N	M	L
CO-04	M	L	M	S	M	L	N	M	M
CO-05	M	L	M	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I : OIL HYDRAULIC SYSTEMS 9

Hydraulic Power Generators - Selection and specification of pumps, pump characteristics - Linear and Rotary Actuators - selection, specification and characteristics - Pressure - direction and flow control valves - relief valves, non-return and safety valves - Hydraulic actuation systems.

UNIT II: HYDRAULIC CIRCUIT DESIGN 9

Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits - industrial circuits – press circuits - hydraulic milling machine - grinding, planning, copying, forklift, earth mover circuits – Design and methodology-Sequential circuits, cascade, circuits - Compound and combination circuit design - selection of components - safety and emergency mandrels.

UNIT III: PNEUMATIC SYSTEMS AND CIRCUIT 9

Pneumatic fundamentals - control elements, position and pressure sensing -logic circuits - switching circuits - fringe conditions - modules and their integration.

UNIT IV: PNEUMATIC CIRCUIT DESIGN 9

Sequential circuits - cascade methods - mapping methods – step counter method - compound circuit design - combination circuit design - hydro pneumatic circuits - Pneumatic equipments - selection of components - design calculations –application.

UNIT V: COMPUTER CONTROL AND MAINTENANCE OF FLUID POWER CIRCUITS 9

Fuzzy logic in fluid power circuits- PLC in fluid powers- PLC ladder diagram – Low cost automation - Robotic circuits - Installation -Fault finding in fluid power circuits.

TOTAL: 45 PERIODS

REFERENCES:

1. Bolton W., “Pneumatic and Hydraulic Systems ", Butterworth - Heineman, 2011.
2. Esposito. A., “Fluid power with Applications ",7th Prentice Hall, 2013.
3. Majumdar, S., “Oil Hydraulic Systems: Principles And Maintenance”, Tata McGraw-Hill Education, 2001.
4. Majumdar, S.R., “Pnuematic Systems: Principles And Maintenance”, Tata McGraw-Hill Education, 2001.
5. Parr, A., “Hydraulics and Pneumatics ", (HB), Jaico Publishing House, 2016.
6. Pease D.A. and Pippenger J.J., “Basic Fluid Power ", Prentice Hall, 2017.
7. Pessen, D.W., “Industrial Automation Circuit Design and Components”, Wiley India Pvt. Ltd., Reprint 2011.

CM45D5	ELECTRONICS MANUFACTURING TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on wafer preparation and PCB fabrication
- To introduce Through Hole Technology (THT) and Surface Mount Technology (SMT) with various types of electronic components
- To elaborate various steps in Surface Mount Technology (SMT)
- To be acquainted with various testing and inspection methods of populated PCBS
- To outline repair, rework and quality aspects of Electronic assemblies.

Course Outcome – Cos		Cognitive Skill
CO-01	Realize wafer preparation and PCB fabrication.	A
CO-02	Elaborate on through hole and surface mount technology components.	A,E
CO-03	Discuss the steps involved in soldering post solder cleaning and its importance in PCB manufacturing.	U
CO-04	Improve knowledge on surface mount technology.	A
CO-05	Locate the required inspections, testing and repair methods used in PCB.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	L	N	M	M
CO-02	S	L	M	M	M	L	N	L	L
CO-03	M	L	M	M	M	L	N	M	L
CO-04	M	L	M	S	M	L	N	M	M
CO-05	M	L	M	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO ELECTRONICS MANUFACTURING 9

History, definition, wafer preparation by growing, machining, and polishing, diffusion, microlithography, etching and cleaning, Printed Circuit Boards, types- single sided, double sided, multi layer and flexible printed circuit board, design, materials, manufacturing, inspection. Electronic packaging – Through Hole Technology (THT) and Surface Mount Technology (SMT)

UNIT II: COMPONENTS AND PACKAGING 8

Through-hole components – axial, radial, multi leaded, odd form. Surface mount components-active, passive. Interconnections - chip to lead interconnection, die bonding, wire bonding, TAB, Flip chip, chip on board, multi chip module, direct chip array module, leaded, leadless, area array and embedded packaging, miniaturization and trends.

UNIT III: SOLDERING AND CLEANING 9

Soldering theory, effect of elemental constituents on wetting, microstructure and soldering, solder paste technology – fluxing reactions, flux chemistry, solder powder, solder paste composition andmanufacturing, solder paste rheology, Wave soldering. Adhesive and solder paste application. solder system variables. soldering temperature profile. Reflow soldering - profile generation and control, soldering quality and defects. Post solder cleaning and selection. Measurement of cleanliness levels.

UNIT IV: SURFACE MOUNT TECHNOLOGY: 9

SMT Equipment and Material Handling Systems, Handling of Components and Assemblies - Moisture Sensitivity and ESD, Safety and Precautions Needed, IPC and Other Standards, Stencil Printing Process, solder paste storage and handling, stencils and squeegees, process parameters, quality control - Component Placement, Equipment Type, Chip shooter, IC placer, Flexibility, Accuracy of Placement, Throughput, reflow soldering, adhesive, underfill and encapsulation process, applications, storage and handling, process & parameters.

UNIT V: INSPECTION, TEST AND REWORK FOR PCB 9

Inspection Techniques, Equipment and Principle – AOI, X-ray. stencil printing process- defects & corrective action, component placement process - defects & corrective action, Reflow Soldering Process- defects & corrective action, underfill and encapsulation Process- defects & corrective action, Testing of assemblies, In-circuit testing (ICT), functional testing, concept of yield, Rework and Repair, tools, rework criteria and process, Design for - Manufacturability, Assembly, Reworkability, Testing, Reliability and Environment.

TOTAL: 45 PERIODS

REFERENCES:

1. Coombs, Jr. C.E., " Printed Circuits Handbook " Mc Graw-Hill Hand books Sixth Edition, 2008.
2. Gurnett, K.W., "Surface Mount Handbook", NewnesElsevier , 2005.
3. Landers, T.L., "Electronics Manufacturing Processes", Prentice Hall, 2003.
4. Lee, N.C., "Reflow Soldering Process and Trouble Shooting – SMT, BGA, CSP and Flip Chip Technologies", Newnes Elsevier, 2001.
5. Prasad R.P., "Surface Mount Technology: Principles and Practice", New York: Chapman and Hall, 2008.
6. Seraphim, D., Lasky, R.C. and Che-Yu Li, "Principles of Electronic Packaging" MCGraw Hill, 2015.
7. Zant, P.V., " Microchip Fabrication – a practical guide to semiconductor processing "McGraw Hill, 2000.

CM45D6	ENVIRONMENT CONSCIOUS MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart knowledge on sustainable manufacturing concepts and standards
- To gain an insight on green manufacturing initiatives
- To get familiarized with environment conscious design
- To explore methods that support environmental friendly manufacturing
- To understand the Life Cycle Assessment process

Course Outcome – Cos		Cognitive Skill
CO-01	Take advantage of sustainable manufacturing concepts and standards	U
CO-02	Deploy green manufacturing initiatives	A,R
CO-03	Apply the environment conscious design	A
CO-04	Take advantage of environmental friendly manufacturing methods	A
CO-05	Apply the Life Cycle Assessment process	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	S	L	M	M	N	M	M
CO-02	S	M	S	L	M	M	N	L	L
CO-03	M	L	S	L	M	M	N	M	L
CO-04	M	M	S	L	M	M	N	M	M
CO-05	M	S	S	L	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I : SUSTAINABLE MANUFACTURING AND EMS 9

Sustainable Manufacturing - Concepts and Methodologies to Help Promote Industrial Ecology - ISO 14000 series standards - Concepts of ISO 14001 - requirements of ISO 14001 – Environmental Management System benefits - Environmentally Conscious Manufacturing.

UNIT II: GREEN MANUFACTURING 9

Green Design and Quality Initiatives - Environmental Cost Accounting and Business Strategy - Accounting for an Environmentally Conscious Setting - The Development of Eco labelling Schemes

UNIT III: RECYCLING 9

Recycling as Universal Resource Policy - Innovation Towards Environmental Sustainability In Industry - A Systematic Framework for Environmentally Conscious Design

UNIT IV: ENVIRONMENTAL ATTRIBUTES OF MANUFACTURING 10

Environmental Attributes of Manufacturing Processes - Environmental Decision Support Systems - Decision Models for Reverse Production System Design - Environmentally Sound Supply Chain Management

UNIT V: LIFE CYCLE ASSESSMENT 8

Life Cycle Assessment - Multipath way and Cumulative Risk Assessment - Reclamation And Recycling of Waste

TOTAL: 45 PERIODS

REFERENCES:

1. Besterfield, D.H., Besterfield, C.M., Besterfield, G.H. and Besterfield, M.S.,"Total Quality Management ", Pearson Education, 2002.
2. Gupta, S.M. and Lambert, A.J.D., "Environment Conscious Manufacturing", CRC Press, 2008.
3. Madu, C.N., "Handbook of Environmentally Conscious Manufacturing", Kluwer Academic Publisher, 2001.
4. Swamidass, P.M., "Encyclopedia of Production and Manufacturing Management", Kluwer Academic Publisher, 2000.

CM45D7	EVOLUTIONARY COMPUTATIONL	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To impart the knowledge in optimization,
- To explore multi objective optimization,
- To learn evolutionary algorithms,
- To understand Evolutionary strategies and programming.
- To get familiarized in Multi-Objective Evolutionary algorithm.

Course Outcome – Cos		Cognitive Skill
CO-01	Demonstrate principles of optimization process	U
CO-02	Make use of multi response optimization	A
CO-03	Inference to the evolutionary programming	An
CO-04	Evaluate the process parameters for optimization	E
CO-05	Apply optimization techniques in mechanical component design	A

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	M	S	M	M	M	M	N	M	M
CO-02	M	S	L	M	M	M	N	L	L
CO-03	M	S	L	M	M	M	N	M	L
CO-04	M	S	L	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO OPTIMIZATION 9

Introduction to optimization - single and multi objective optimization - Evolutionary algorithms - principles of multi objective optimization.

UNIT II: MULTI OBJECTIVE OPTIMIZATION 9

Convex programming, Karush-Kuhn-Tucker conditions, Direct functional evaluation and derivative based optimization techniques;

UNIT III: EVOLUTIONARY ALGORITHMS 9

Simulated annealing, Tabu search; NFL theorem; Biological principles of evolution, General scheme of EAs, Representation, Selection schemes, Population evaluation, Variation operators; Constraint handling; Schema theorem; Binary coded genetic algorithm, Real coded genetic algorithm.

UNIT IV: EVOLUTIONARY STRATEGIES AND EVOLUTIONARY PROGRAMMING 9

Evolutionary strategies, Evolutionary programming, genetic programming, Differential evolution, Particle swarm optimization;

UNIT V: APPLICATIONS OF MULTI-OBJECTIVE EVOLUTIONARY ALGORITHMS 9

Pareto-optimality, Multi-objective evolutionary algorithms; Statistical analysis of EC techniques; Customization in EAs; Applications of multi-objective evolutionary algorithms - Mechanical component design - Truss-structure design - Other applications.

TOTAL: 45 PERIODS

REFERENCES:

1. Back, T., Fogal, D. B. and Michalewicz, Z., "Handbook of Evolutionary Computation", Oxford University Press, 2005.
2. Clerc, M.,"Particle Swarm Optimization", ISTE, 2006.
3. Deb, K., "Multi-objective Optimization using Evolutionary Algorithms", Wiley, 2001.
4. Fogel, D. B., "Evolutionary Computation, The Fossil Record", IEEE Press, 2003.
5. Goldberg, D., "Genetic Algorithms in Search, Optimization, and Machine Learning", Addison Wesley, 2006.
6. Price, K. ,Storn, R. M. , and Lampinen, J. A. ,"Differential Evolution: A Practical Approach to Global Optimization", Springer, 2005.

CM45D8	SUSTAINABLE MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

- To be acquainted with sustainability in manufacturing and its evaluation.
- To provide knowledge in environment and social sustainability.
- To provide the student with the knowledge of strategy to achieve sustainability.
- To familiarize with trends in sustainable operations.
- To create awareness in current sustainable practices in manufacturing industry.

Course Outcome – Cos		Cognitive Skill
CO-01	Discuss the importance of economic sustainability.	U
CO-02	Describe the importance of sustainable practices.	A,R
CO-03	Identify drivers and barriers for the given conditions.	An
CO-04	Formulate strategy in sustainable manufacturing.	A
CO-05	Plan for sustainable operation of industry with environmental, cost consciousness	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	L	N	M	M
CO-02	S	M	M	M	M	L	N	L	L
CO-03	M	L	S	M	M	L	N	M	L
CO-04	M	M	S	S	M	L	N	M	M
CO-05	M	L	M	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: ECONOMIC SUSTAINABILITY 9

Industrial Revolution-Economic sustainability: globalization and international issues- Sustainability status - Emerging issues- Innovative products- Reconfiguration manufacturing enterprises - Competitive manufacturing strategies - Performance evaluation- Management for sustainability - Assessments of economic sustainability

UNIT II: SOCIAL AND ENVIRONMENTAL SUSTAINABILITY 9

Social sustainability – Introduction-Work management -Human rights - Societal commitment - Customers -Business practices -Modelling and assessing social sustainability. Environmental issues pertaining to the manufacturing sector: Pollution - Use of resources -Pressure to reduce costs - Environmental management: Processes that minimize negative environmental impacts - environmental legislation and energy costs - need to reduce the carbon footprint of manufacturing Operations - Modelling and assessing environmental sustainability

UNIT III: SUSTAINABILITY PRACTICES 9

Sustainability awareness - Measuring Industry Awareness-Drivers and barriers -Availability of sustainability indicators -Analysis of sustainability practicing -Modeling and assessment of sustainable practicing -Sustainability awareness -Sustainability drivers and barriers -Availability of sustainability indicators- Designing questionnaires- Optimizing Sustainability Indexes-Elements – Cost and time model

UNIT IV: MANUFACTURING STRATEGY FOR SUSTAINABILITY 9

Concepts of competitive strategy and manufacturing strategies and development of a strategic improvement programme - Manufacturing strategy in business success strategy formation and formulation - Structured strategy formulation - Sustainable manufacturing system design options - Approaches to strategy formulation - Realization of new strategies/system designs

UNIT V: TRENDS IN SUSTAINABLE OPERATIONS 9

Principles of sustainable operations - Life cycle assessment manufacturing and service activities - Influence of product design on operations - Process analysis - Capacity management – Quality management -Inventory management - Just-In-Time systems - Resource efficient design - Consumerism and sustainable well-being

TOTAL: 45 PERIODS

REFERENCES:

1. Davim J.P., “Sustainable Manufacturing”, John Wiley & Sons., United States, 2010, ISBN: 978-1- 848-21212-1.
2. Ibrahim Garbie, “Sustainability in Manufacturing Enterprises Concepts, Analyses and Assessments for Industry 4.0”, Springer International Publishing., United States, 2016, ISBN-13: 978- 3319293042.
3. Jovane F., Ęmper, W.E. and Williams, D.J., “The ManuFuture Road: Towards Competitive and Sustainable High-Adding-Value Manufacturing”, Springer,2009, United States, ISBN 978-3-540- 77011-4.
4. Kutz M., “Environmentally Conscious Mechanical Design”, John Wiley & Sons., United States, 2007, ISBN: 978-0-471-72636-4.
5. Seliger G., “Sustainable Manufacturing: Shaping Global Value Creation”, Springer, United states, 2012, ISBN 978-3-642-27289-9.

CM45D9	INTELLIGENT PRODUCT DESIGN AND MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the basic principles of intelligent product design and manufacturing.
- To study the various techniques of knowledge representation.
- To study the different the modelling techniques in intelligent product design and manufacturing.
- To apply the neural networks in manufacturing systems.
- To understand and develop the web based CAD/CAM internet model.

Course Outcome – Cos		Cognitive Skill
CO-01	Demonstrate Internet technology in manufacturing Industry	U
CO-02	Make use of techniques of Knowledge Representation	R
CO-03	Analysis of various CAD/CAM system	An
CO-04	Apply neural networks for intelligent process monitoring and control	A
CO-05	Develop web based CAD/CAM internet model	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	M	M	M	L	N	M	M
CO-02	S	S	L	M	M	L	N	L	L
CO-03	M	M	S	M	M	L	N	M	L
CO-04	M	M	S	S	M	L	N	M	M
CO-05	M	M	L	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION TO INTELLIGENT DESIGN AND MANUFACTURING 9

Need - Internet technology and Manufacturing Industry - Digital enterprises - Manufacturing portals – Benefits.

UNIT II: TECHNIQUES OF KNOWLEDGE REPRESENTATION 9

Artificial Neural Networks, Fuzzy Logic, Genetic Algorithms, Expert Systems with case studies.

UNIT III: INTELLIGENT PRODUCT MODELING TECHNIQUES 9

Intelligent CAD systems, integrating product and process design, manufacturing analysis and CAD/CAM integration, design methodology for automated manufacture, the impacts of intelligent process control on product design, and fuzzy knowledge-based controller design.

UNIT IV: APPLICATION OF NEURAL NETWORKS 9

Neural Networks for Intelligent Process Monitoring and Control : Applications to CNC machining, Metal Forming - Intelligent Manufacturing Planning, Scheduling and Control - Intelligent Assembly and Layout Planning.

UNIT V: INTERNET BASED COLLABORATIVE CAD/CAM 9

Applications to web based CAD, CAPP, CNC, Assembly planning, and Rapid Prototyping - Challenging issues of Collaborative CAD/CAM.

TOTAL: 45 PERIODS

REFERENCES:

1. Dagli, C.H., "Intelligent systems in design and manufacturing", ASME, 2000.
2. Huang, G.Q. and Mak, K.L., "Internet Applications in Product design and Manufacturing" ,Springer, 2003.
3. Kusiak, A., "Intelligent Design and Manufacturing", Wiley-Inderscience, 2005.
4. Parsaei, H.R. and Jamshidi, M., "Design and implementation of intelligent manufacturing systems", Prentics Hall, 2010.

CM45E1	INTELLIGENT MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

To know the concepts of Artificial Intelligence

To Practice the methods of solving problems using Artificial Intelligence

To build components of intelligent decision support system for Manufacturing To understand intelligent systems and its troubleshooting methods

To investigate and deploy Artificial Intelligence for future smart manufacturing factories.

Course Outcome – Cos		Cognitive Skill
CO-01	Apply various knowledge-based techniques	A
CO-02	Build components of intelligent decision support system	A,R
CO-03	Adopt intelligent system for Manufacturing	U
CO-04	Demonstrate the concepts of Artificial Intelligence	A
CO-05	Solve problems using Artificial Intelligence	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	M	M	M	L	N	M	M
CO-02	S	S	L	M	M	L	N	L	L
CO-03	M	M	S	M	M	L	N	M	L
CO-04	M	M	S	S	M	L	N	M	M
CO-05	M	M	L	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Components of manufacturing – Soft and Hard Automation – Flexible Manufacturing Cell – Flexible handling methods -Basic concepts of Artificial intelligence and expert systems – Intelligent System Components -System architecture and Data flow – System Operations.

UNIT II: MANUFACTURING COMPONENTS OF AI 9

manufacturing components of intelligent manufacturing Aspects of intelligence and AI Requirements of AI languages, LISP & PROLOG – Simple programs

UNIT III: BUILDING OF KNOWLEDGE BASED SYSTEMS 9

Knowledge engineering-protocol analysis -fuzzy logic -Semantic networks, Learning systems Knowledge Engineering Knowledge representation – Knowledge acquisition and optimization - Knowledge based approaches to design mechanical parts and mechanisms and design for automated assembly.

UNIT IV: INTELLIGENT SYSTEMS 9

Knowledge based system for material selection – Intelligent process planning system. Intelligent system for equipment selection -Intelligent system for project management & factory monitoring. Inference engine Vision programmes-factory vision systems -machine learning

UNIT V: FACTORIES OF FUTURE 9

The role of Artificial Intelligence in the factory of the future Features of Experts systems - applications in manufacturing planning and control – Intelligent systems. Scheduling in manufacturing – scheduling the shop floor – Diagnosis & trouble shooting.

TOTAL 45 PERIODS

REFERENCES:

1. Andrew Kussiak, "Intelligent Manufacturing Systems", Prentice Hall, 2000.
2. Kenneth R.Baker, "Introduction to sequencing and scheduling", John Wiley & Sons, New York, 2009.
3. Richard W. Conway, William Maxwell and Louis W. Miller, "Theory of Scheduling", Dover Publications, 2003.
4. Rich,E., "Artificial Intelligence", McGraw Hill, 2016.
5. Simons, G.L, "Introducing Artificial Intelligence", NCC Pub, 2000.

CM45E2	ENTERPRISE RESOURCE PLANNING	L	T	P	C
		3	0	0	3

OBJECTIVES:

Describe an idea about ERP

Creating awareness of core and extended modules of ERP Extract knowledge of ERP implementation cycle

Gaining knowledge about effects of ERP after its implementation. Understanding the emerging trends on ERP.

Course Outcome – Cos		Cognitive Skill
CO-01	Get an idea about ERP	U
CO-02	Awareness of core and extended modules of ERP	R
CO-03	Knowledge of ERP implementation cycle	U
CO-04	Gain knowledge about effects of ERP after its implementation.	U
CO-05	Understand the emerging trends on ERP	U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	M	M	N	M	M
CO-02	S	M	L	M	M	M	N	L	L
CO-03	M	L	S	M	M	M	N	M	L
CO-04	M	M	S	S	M	M	N	M	M
CO-05	M	S	L	S	M	M	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Overview of enterprise systems – Evolution - Risks and benefits - Fundamental technology - Issues to be consider in planning design and implementation of cross functional integrated ERP systems.

UNIT II: ERP SOLUTIONS AND FUNCTIONAL MODULES 9

Overview of ERP software solutions- Small, medium and large enterprise vendor solutions, BPR, and best business practices - Business process Management, Functional modules.

UNIT III: ERP IMPLEMENTATION 9

Planning Evaluation and selection of ERP systems - Implementation life cycle - ERP implementation, Methodology and Frame work- Training – Data Migration. People Organization in implementation- Consultants, Vendors and Employees**.**

UNIT IV: POST IMPLEMENTATION 9

Maintenance of ERP- Organizational and Industrial impact; Success and Failure factors of ERP Implementation.

UNIT V: EMERGING TRENDS ON ERP 9

Extended ERP systems and ERP add-ons -CRM, SCM, Business analytics - Future trends in ERP systems-web enabled, Wireless technologies, cloud computing

TOTAL: 45 PERIODS

REFERENCES:

1. Alexis Leon, Enterprise Resource Planning, second edition, Tata McGraw-Hill, 2008.
2. Jagan Nathan Vaman, ERP in Practice, Tata McGraw-Hill, 2008.
3. MahadeoJaiswal and Ganesh Vanapalli, ERP Macmillan India, 2009.
4. Sinha P. Magal and Jeffery Word, Essentials of Business Process and Information System, Wiley India, 2012.
5. Vinod Kumar Grag and N.K. Venkitakrishnan, ERP- Concepts and Practice, Prentice Hall of India, 2006.

CM45E3	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce MEMS, Microsystems, materials and working of MEMS and Microsystems
- To explain the scaling laws in miniaturization and design for microsystems
- To familiarize with different microsystem fabrication processes.
- To learn packaging, interfaces and assembly of microsystems
- To gain knowledge in different measurement and characterization methods for MEMS.

Course Outcome – Cos		Cognitive Skill
CO-01	Explain the concept of Micro Electro Mechanical systems	U
CO-02	Develop micro system design	A,R
CO-03	Identify the elements of MEMS system	U,An
CO-04	Determine the scaling and design methods	A
CO-05	Examine the micro metrology and characterization	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	L	M	M	S	L	N	M	M
CO-02	S	M	L	M	S	L	N	L	L
CO-03	S	L	S	M	S	L	N	M	L
CO-04	S	M	S	S	M	L	N	M	M
CO-05	S	L	L	S	M	L	N	M	M

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: INTRODUCTION 9

Overview of MEMS and Microsystems: MEMS and Microsystems, Evolution of Micro fabrication, Microsystems and Microelectronics, Microsystems and miniaturization-Materials for MEMS and Microsystems: substrates and wafers, active substrate materials, Silicon, Gallium Arsenide, Piezoelectric Crystals, Polymers, Packaging materials-Working principles of Microsystems: micro sensors, micro actuation, MEMS with micro actuators, Micro accelerometers, micro fluidics-Applications of Microsystems in various industries.

UNIT II: MECHANICS, SCALING AND DESIGN 9

Engineering Mechanics for Microsystems design: Introduction, Static bending of Thin Plates, Mechanical Vibration, Thermomechanics, Thermofluid, Engineering and micro system design, Laminar fluid flow, Incompressible fluid Flow, Heat conduction in solids-Scaling Laws in Miniaturization, Introduction to scaling, Scaling in (Electrostatic forces electromagnetic forces, Electricity, fluid mechanics, heat transfer)-Microsystems Design: Design Consideration, Process design, Mechanical Design, Design of Micro fluidic Network systems

UNIT III: MICRO SYSTEM FABRICATION PROCESSES 11

Introduction- Photolithography- Ion implantation- Chemical Vapor Deposition-Physical Vapor Deposition - clean room- Bulk micromachining :etching, isotropic and anisotropic etching, wet and dry etching- Surface micro machining :process, mechanical problems associated with surface micro machining- LIGA process :general description, materials for substrates and photo resists-SLIGA process-Abrasive jet micro machining-Laser beam micro machining- Micro Electrical

Discharge Micro Machining –Ultrasonic Micro Machining- Electro chemical spark micro machining- Electron beam micro machining-Focused Ion Beam machining

UNIT IV: MICROSYSTEMS PACKAGING 8

Introduction - Microsystems Packaging-Interfaces in Microsystems Packaging-Essential Packaging Technologies- Die preparation, surface bonding, wire bonding, sealing- Three dimensional Packaging- Assembly of Microsystems, Signal Mapping and Transduction

UNIT V: MICROMETROLOGY AND CHARACTERIZATION 8

Microscopy and visualization- Lateral and vertical dimension- optical microscopy, Scanning white light interferometry, Confocal Laser scanning microscopy, Molecular measuring machine, Micro coordinate measuring machine- Electrical measurements – Physical and chemical analysis – XRD- SEM - Secondary Ion mass spectrometry- Auger Electron Spectroscopy, SPM

TOTAL: 45 PERIODS

REFERENCES:

1. Franssila, S., “Introduction to Micro Fabrication” John Wiley & sons Ltd, 2004.ISBN:470-85106-6.
2. Hak M.G., “MEMS Handbook”, CRC Press, ISBN: 8493-9138-5, 2006.
3. Hsu, T.R., “MEMS & Microsystems Design and Manufacture”, Tata McGraw Hill, 2002,ISBN: 9780070487093.
4. Jackson, M.J., “Microfabrication and Nanomanufacturing” Second edition,Taylor and Francis 2008.
5. Jain, V.K., “Introduction to Micromachining”Second edition, Narosa Publishing House, 2018.
6. McGeough, J.A., “Micromachining of Engineering Materials”, CRC Press, ISBN: 0824706447, 2001.

CM45E4	PRODUCT LIFECYCLE MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To understand history, concepts and terminology of PLM
2. To understand functions and features of PLM/PDM
3. To understand different modules offered in commercial PLM/PDM tools
4. To demonstrate PLM/PDM approaches for industrial applications
5. To Use PLM/PDM with legacy data bases, CAx& ERP systems

Course Outcome – Cos		Cognitive Skill
CO-01	Summarize the history, concepts and terminology of PLM	U
CO-02	Use the functions and features of PLM/PDM	A,R
CO-03	Use different modules offered in commercial PLM/PDM tools.	R
CO-04	Implement PLM/PDM approaches for industrial applications.	A
CO-05	Integrate PLM/PDM with legacy data bases, CAx& ERP systems.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	L	S	S	M	L	S	L	M	L
CO-02	M	M	S	M	L	M	L	M	L
CO-03	L	S	S	M	L	S	L	M	L
CO-04	L	S	S	M	L	S	L	M	L
CO-05	M	M	S	S	M	M	L	M	L

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: HISTORY, CONCEPTS AND TERMINOLOGY OF PLM 9

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM).PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

UNIT II: PLM/PDM FUNCTIONS AND FEATURES 9

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration.

UNIT III: DETAILS OF MODULES IN APDM/PLM SOFTWARE 9

Case studies based on top few commercial PLM/PDM tools

UNIT IV: ROLE OF PLM ININDUSTRIES 9

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organization, users, product or service, process performance.

UNIT V: BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE 9

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP

TOTAL:45PERIODS

REFERENCES:

1. Antti Saaksvuori and Anselmi Immonen, "Product Lifecycle Management", Springer Publisher, 2008 (3rd Edition).
2. International Journal of Product Lifecycle Management, Inderscience Publishers.
3. Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.
4. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
5. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
6. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

CM45E5	INDUSTRY 4.0	L	T	P	C
		3	0	0	3

OBJECTIVES:

The students will be able to

1.Understand Industry 4.0

2.Apply IOT and IOT for Industry 4.0

3. Understand CPS for Industry 4.0

Course Outcome – Cos		Cognitive Skill
CO-01	Use Industry 4.0 for Industrial Applications	A
CO-02	Use IoT and IIoT for Industry 4.0	A,R
CO-03	Apply smart devices Industrial Applications	A
CO-04	Use Industry 4.0 for Cyber Physical Systems	A
CO-05	Use Industry 4.0 for cloud computing.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	M	L	L	M	S
CO-02	S	S	S	S	M	L	L	M	S
CO-03	S	S	S	S	M	L	L	M	S
CO-04	S	S	S	S	M	L	L	M	S
CO-05	S	S	S	S	M	L	L	M	S

UNIT I: **9**

Introduction to Industry 4.0 The Various Industrial Revolutions - Digitalisation and the Networked Economy - Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0 - Comparison of Industry 4.0 Factory and Today's Factory - Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation

UNIT II: **9**

Road to Industry 4.0 - Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services - Smart Manufacturing - Smart Devices and Products - Smart Logistics - Smart Cities - Predictive Analytics

UNIT III: **9**

System, Technologies for enabling Industry 4.0–Cyber Physical Systems - Robotic Automation and

Collaborative Robots - Support System for Industry 4.0 - Mobile Computing - Cyber Security

UNIT IV: **9**

Role of data, information, knowledge and collaboration in future organizations - Resource- based view of a firm - Data as a new resource for organizations - Harnessing and sharing knowledge in organizations - Cloud Computing Basics -Cloud Computing and Industry 4.0

UNIT V: **9**

Industry 4.0 IIoT case studies - Opportunities and Challenges - Future of Works and Skills for Workers in the Industry 4.0 Era - Strategies for competing in an Industry 4.0 world – Society 5.0

TOTAL : 45 PERIODS

REFERENCE:

1. Alasdair Gilchrist, Industry 4.0: The Industrial Internet of Things.
2. ArsheepBahga, Internet of Things: A Hands-On Approach.

OPEN ELECTIVE

Sl.No.	SUBJECT CODE	SUBJECT NAME	L	T	P	C
7.	OE45D1	Research Methodology and IPR	2	0	0	2
8.	OE45D2	Business Analytics	3	0	0	3
9.	OE45D3	Industrial Safety	3	0	0	3
10.	OE45D4	Operations Research	3	0	0	3
11.	OE45D5	Composite Materials	3	0	0	3
12.	OE45D6	Waste to Energy	3	0	0	3

OE45D1	RESEARCH METHODOLOGY & IPR	L	T	P	C
		2	0	0	2

OBJECTIVES:

To prepare students for the practical application of research methodologies and intellectual property knowledge in their future academic or professional endeavours**.**

Course Outcome – Cos		Cognitive Skill
CO-01	Illustrate research problem formulation.	A,R
CO-02	Analyze research related information and research ethics.	A,R
CO-03	Correlate the results of any research article with other published results and write a review article in the field of engineering.	A, R
CO-04	Explain why intellectual property rights (IPR) will play such a significant role in the development of people and nations, and briefly discuss the necessity to spread awareness of IPR among students in general and engineers in particular.	A,R
CO-05	Discuss how IPR protection encourages innovators to conduct additional research and invest in R & D, which results in the development of new and improved products, which in turn leads to economic growth and societal benefits.	E,R

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	M	M	M	M	S
CO-02	S	S	S	S	M	M	M	M	S
CO-03	S	S	S	S	M	M	M	M	S
CO-04	S	S	S	S	M	M	M	M	S
CO-05	S	S	S	S	M	M	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: RESEARCH METHODOLOGY 6

Meaning of research problem, Sources of research problem, Criteria and Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations.

UNIT II: LITERATURE SURVEY AND ETHICS 6

Effective literature studies approaches - analysis Plagiarism - Research ethics.

UNIT III: TECHNICAL WRITING 6

Effective technical writing - how to write a manuscript/ responses to reviewers comments - preparation of research article/ research report - Writing a Research Proposal - presentation and assessment by a review committee.

UNIT IV: INTELLECTUAL PROPERTY RIGHTS 6

Nature of Intellectual Property: Patents, Designs, Trade Mark and Copyright - Process of Patenting and Development: technological research, innovation, patenting & development - Procedure for grants of patents - Patenting under PCT.

UNIT V: PATENT RIGTS AND NEW DEVELOPMENTS IN IPR 6

Scope of Patent Rights - Licensing and transfer of technology - Patent information and databases - Geographical Indications - New Developments in IPR: Administration of Patent System - New developments in IPR - IPR of Biological Systems - Computer Software etc - Traditional knowledge.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. C.R.Kothari, "Research Methodology", 3rd Edition, New Age International, 2017.
2. Ranjit Kumar, "Research Methodology – A Step by Step for Beginner's", 2nd Edition, Pearson, Education, 2016.
3. Ann M. Korner, Guide to Publishing a Scientific paper, Bioscript Press 2004.
4. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.
5. Kompal Bansal &Parshit Bansal, "Fundamentals of IPR for Beginner's", 1st Edition, BS Publications, 2016.

REFERENCES:

1. Kothari, C. R. Research Methodology - Methods and Techniques, New Age International publishers, New Delhi, 2004.
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students', Juta & Company, 1996.
3. Robert P. Merges, Peter S. Menell and Mark A. Lemley, "Intellectual Property in New Technological Age", Aspen Publishers, 2016.
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974. 7. Asimov , "Introduction to Design", Prentice Hall, 1962.

WEB RESOURCES:

1. https://nptel.ac.in/courses/106/105/106105077/

OE45D2	BUSINESS ANALYTICS	L	T	P	C
		3	0	0	3

OBJECTIVES:

The objectives of a "Business Analytics" typically revolve around providing students with a comprehensive understanding of analytical techniques and tools used in the business context.

Course Outcome – Cos		Cognitive Skill
CO-01	Understand the role of business analytics within an organization.	A
CO-02	Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.	A,R
CO-03	To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.	U, A
CO-04	To become familiar with processes needed to develop, report, and analyze business data.	A
CO-05	Use decision-making tools/Operations research techniques.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	M	M	M	M	S
CO-02	S	S	S	S	M	M	M	M	S
CO-03	S	S	S	S	M	M	M	M	S
CO-04	S	S	S	S	M	M	M	M	S
CO-05	S	S	S	S	M	M	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: **9**

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

UNIT II: **9**

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

UNIT III: **9**

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes. Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

UNIT IV: **9**

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models.

Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

UNIT V: **9**

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making, Recent Trends in : Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.

   Business Analytics by James Evans, persons Education.

OE45D3	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

OBJECTIVES:

The objective of the industrial safety subject is to ensure the well-being and protection of individuals working in industrial settings.

Course Outcome - COs		Cognitive Skill
CO-01	To understand the basic principles and knowledge of accident prevention.	R & U
CO-02	To understand the basic principles and knowledge of safety in material handling.	R & U
CO-03	To understand the basic principles and knowledge of safety in chemical industries.	R & U
CO-04	To understand the basic principles and knowledge of environmental impact assessment.	R & U
CO-05	To understand the basic principles and knowledge of health safety and environment regulation.	R & U

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	S	M	M	S	S
CO-02	S	S	S	S	S	M	M	S	S
CO-03	S	S	S	S	S	M	M	S	S
CO-04	S	S	S	S	S	M	M	S	S
CO-05	S	S	S	S	S	M	M	S	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: **9**

Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II: **9**

Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III: **9**

Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV: **9**

Fault tracing: Fault tracing-concept and importance, decision treeconcept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic,automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V: **9**

Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance.

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London

OE45D4	OPERATIONS RESEARCH	L	T	P	C
		3	0	0	3

OBJECTIVES:

Students understanding and practical knowledge of optimization techniques, mathematical modelling, and related topics in the field of operations research.

Course Outcome – Cos		Cognitive Skill
CO-01	Students should be able to apply dynamic programming to solve problems of discrete and continuous variables.	A
CO-02	Students should be able to apply the concept of non-linear programming.	A,R
CO-03	Students should be able to carry out sensitivity analysis.	A
CO-04	Students should be able to model the real-world problem and simulate it.	A
CO-05	Students able to understand the concept of Competitive Models.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	M	M	M	M	S
CO-02	S	S	S	S	M	M	M	M	S
CO-03	S	S	S	S	M	M	M	M	S
CO-04	S	S	S	S	M	M	M	M	S
CO-05	S	S	S	S	M	M	M	M	S

S- Strong, M- Medium, L-Low, N- Not Relevant

UNIT I: **9**

Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT II: **9**

Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming.

UNIT III: **9**

Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT.

UNIT IV: **9**

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

UNIT V: **9**

Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation.

TOTAL: 45 PERIODS

REFERENCE BOOKS:

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010.

OE45D5	COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

Students should grasp the fundamental concepts of composite materials, including the types of constituents (matrix and reinforcement), their properties, and the rationale behind combining them.

Course Outcome – Cos		Cognitive Skill
CO-01	Learn to analyse and predict the mechanical and physical properties of composite materials based on the characteristics of their individual components.	A
CO-02	Gain the ability to select appropriate materials and design composite structures based on the desired performance criteria.	A,R
CO-03	Understand various fabrication techniques for composite materials, including lay-up processes, molding, and curing methods.	A
CO-04	Acquire skills in quality control and testing procedures for composite materials.	A
CO-05	Understand how to make informed choices based on both performance and environmental factors.	E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	M	L	L	M	S
CO-02	S	S	S	S	M	L	L	M	S
CO-03	S	S	S	S	M	L	L	M	S
CO-04	S	S	S	S	M	L	L	M	S
CO-05	S	S	S	S	M	L	L	M	S

UNIT I: INTRODUCTION 9

Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II: REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT III: MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT IV: MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT V: STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

TEXT BOOKS:

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

REFERENCES:

1. Hand Book of Composite Materials-ed-Lubin.
2. Composite Materials – K.K.Chawla.

3. Composite Materials Science and Applications – Deborah D.L. Chung.
4. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

OE45D6	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

Gain an understanding of existing waste management systems, including collection, disposal, and recycling processes.

Course Outcome – Cos		Cognitive Skill
CO-01	Explore various technologies used in converting waste into energy, such as incineration, anaerobic digestion, pyrolysis, and gasification.	U, A
CO-02	Understand how to minimize negative environmental effects.	U,A,R
CO-03	Understand the policy and regulatory frameworks governing waste-to-energy projects.	U,A
CO-04	Develop skills in conducting techno-economic analyses for waste-to-energy projects.	U,A
CO-05	Understand the hierarchy of waste management, emphasizing the importance of waste reduction and reuse.	U,E

R- Remember, U-Understand, A-Apply, An-Analyze, E-Evaluate, S- Synthesis

Mapping of Course Outcome with Programme Outcome

PO / CO	PO-A	PO-B	PO-C	PO-D	PO-E	PO-F	PO-G	PO-H	PO-I
CO-01	S	S	S	S	M	L	L	M	S
CO-02	S	S	S	S	M	L	L	M	S
CO-03	S	S	S	S	M	L	L	M	S
CO-04	S	S	S	S	M	L	L	M	S
CO-05	S	S	S	S	M	L	L	M	S

UNIT I: INTRODUCTION TO ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors.

UNIT II: BIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III: BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT IV: BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT V: BIOGAS 9

Properties of biogas (Calorific value and composition) - Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production - Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

REFERENCES:

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.