ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
M.E. MANUFACTURING ENGINEERING
(FULL TIME AND PART TIME) (R-2023)
CHOICE BASED CREDIT SYSTEM

VISION

To develop educational avenues for the students to emerge as disciplined, researchers technocrats and entrepreneurs making transformative impact on establishing a world class society in the domain of Production Engineering and Automation.

MISSION

1. To impart students with knowledge on modern manufacturing and automated systems by incorporating critical thinking, leadership qualities and communication with interpersonal skills.
2. To create a conducive environment for exchange of multi disciplinary ideas towards research, creativity, innovation and entrepreneurship to meet societal needs with optimal solutions.
3. To follow the values of integrity and honesty through curricular, co-curricular and extracurricular activities.

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.E. MANUFACTURING ENGINEERING

(FULL TIME AND PART TIME) (R-2023)

CHOICE BASED CREDIT SYSTEM

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I.	Successful career practicing modern manufacturing techniques and tools, adapting to emerging trends in industries or as an entrepreneur.
II.	Excel scholarly in academics and research organization, by demonstrating analytical and problem solving skills for complex engineering problems.
III.	Sustainable solution provider for societal needs through innovative and inter disciplinary approaches using modern tools.
IV.	Lead and engage diverse teams through effective communication, collaboration and managerial skills, by following ethics and professional standards.

PROGRAMME OUTCOMES (POs):

POs	Programme Outcomes
1	Graduates shall be able to independently carry out research/investigation and development work to solve practical problems.
2	Graduates shall be able to write and present a substantial technical report/document.
3	Graduates shall be familiar with modern concepts of manufacturing techniques and principles.
4	Graduates shall be able to adapt to real time manufacturing systems, materials processing and quality systems.
5	Graduates shall be able to analyse and provide optimum solution to manufacturing challenges using intelligence tools.
6	Graduates shall be able to develop and work with interdisciplinary problems as professional engineers of organisations, innovators or entrepreneurs, catering to industrial and societal needs.

PEO/PO Mapping:

PEO	POs					
	1	2	3	4	5	6
I.	2	2	3	3	3	3
II.	3	3	2	3	3	3
III.	3	2	2	2	3	3
IV.	2	2	2	1	1	2

PROGRAMME ARTICULATION MATRIX OF PG MANUFACTURING ENGINEERING (FULL TIME) (R - 2023)

		COURSE NAME	PO1	PO2	PO3	PO4	PO5	PO6
YEAR I	SEMESTER I	Computational Methods for Manufacturing	2.0	1.0	1.0	1.0	2.0	1.4
		Solid Freeform Manufacturing	2.6	2.4	2.4	2.2	2.6	2.4
		Composite Materials Processing	1.2	1.0	1.0	2	1	1.6
		Advanced Machining and Forming Process	2	2	2	2	2	1.6
		Research Methodology and IPR	3	3	2	-	-	-
		Professional Elective–I						
		Advanced Machining and Forming Laboratory	3.0	2.0	2.0	2.0	2.0	1.0
		Material Processing Laboratory	3.0	2.0	2.0	2.0	2.0	1.0
	SEMESTER II	Finite Element Applications in Manufacturing	3.0	1.8	2.2	2.2	2.2	2.0
		Thin Film Technology	1.8	1.4	1.8	1.6	1.6	1.4
		Quality and Reliability Engineering	2.0	2.0	1.0	1.8	2.0	2.0
		Machine Learning for Intelligent Systems	2.0	1.4	2.0	1.6	1.6	2.0
		Professional Elective–II						
		Professional Elective–III						
		Finite Element Analysis Laboratory	2.7	2.3	2.0	2.3	2.3	2.0
YEAR II	SEMESTER III	Professional Elective–IV						
		Professional Elective–V						
		Professional Elective–VI						
		Professional Elective–VII						
		Project Work - I	3.0	2.0	2.0	2.3	3.0	2.3
		Comprehension	3.0	1.0	2.0	1.0	2.0	1.0
	SEMESTER IV	Project Work – II	3.0	3.0	3.0	3.0	3.0	3.0

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

ANNA UNIVERSITY, CHENNAI

UNIVERSITY DEPARTMENTS

M.E. MANUFACTURING ENGINEERING (FULL TIME)

REGULATIONS - 2023

CHOICE BASED CREDIT SYSTEM

CURRICULUM AND SYLLABI FOR SEMESTER I TO IV

SEMESTER I

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MN3101	Computational Methods for Manufacturing	FC	3	1	0	4	4
2.	CI3151	Solid Freeform Manufacturing	PCC	3	0	0	3	3
3.	MN3102	Composite Materials Processing	PCC	3	0	0	3	3
4.	MN3103	Advanced Machining and Forming Process	PCC	3	0	0	3	3
5.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
6.		Professional Elective–I	PEC	3	0	0	3	3
PRACTICALS								
7.	MN3111	Advanced Machining and Forming Laboratory	PCC	0	0	3	3	1.5
8.	MN3112	Material Processing Laboratory	PCC	0	0	3	3	1.5
			TOTAL	**17**	**2**	**6**	**25**	**22**

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

SEMESTER II

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MN3201	Finite Element Applications in Manufacturing	PCC	3	1	0	4	4
2.	MN3202	Thin Film Technology	PCC	3	0	0	3	3
3.	MN3203	Quality and Reliability Engineering	PCC	3	0	2	5	4
4.	MN3204	Machine Learning for Intelligent Systems	PCC	2	0	2	4	3
5.		Professional Elective–II	PEC	3	0	0	3	3
6.		Professional Elective–III	PEC	3	0	0	3	3
PRACTICALS								
7.	MN3211	Finite Element Analysis Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**1**	**8**	**26**	**22**

SEMESTER III

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Professional Elective–IV	PEC	3	0	0	3	3
2.		Professional Elective– V	PEC	3	0	0	3	3
3.		Professional Elective–VI	PEC	3	0	0	3	3
4.		Professional Elective–VII	PEC	3	0	0	3	3
PRACTICALS								
5.	MN3311	Project Work –I	EEC	0	0	12	12	6
6.	MN3312	Comprehension	EEC	0	0	2	2	1
			TOTAL	**12**	**0**	**14**	**26**	**19**

SEMESTER IV

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1.	MN3411	Project Work –II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS 22+22+19+12= 75

ANNA UNIVERSITY: CHENNAI 600 025

UNIVERSITY DEPARTMENTS

M.E. MANUFACTURING ENGINEERING

(PART TIME) (R - 2023)

CHOICE BASED CREDIT SYSTEM

SEMESTER I

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MN3101	Computational Methods for Manufacturing	FC	3	1	0	4	4
2.	MN3103	Advanced Machining and Forming Process	PCC	3	0	0	3	3
3.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
4.		Professional Elective–I	PEC	3	0	0	3	3
PRACTICALS								
5.	MN3111	Advanced Machining and Forming Laboratory	PCC	0	0	3	3	1.5
			TOTAL	**11**	**2**	**3**	**16**	**14.5**

SEMESTER II

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	CI3151	Solid Freeform Manufacturing	PCC	3	0	0	3	3
2.	MN3102	Composite Materials Processing	PCC	3	0	0	3	3
3.		Professional Elective-II	PEC	3	0	0	3	3
4.		Professional Elective–III	PEC	3	0	0	3	3
PRACTICALS								
5.	MN3112	Material Processing Laboratory	PCC	0	0	3	3	1.5
			TOTAL	**12**	**0**	**3**	**15**	**13.5**

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

SEMESTER III

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MN3201	Finite Element Applications in Manufacturing	PCC	3	1	0	4	4
2.	MN3202	Thin Film Technology	PCC	3	0	0	3	3
3.		Professional Elective–IV	PEC	3	0	0	3	3
PRACTICALS								
4.	MN3211	Finite Element Analysis Laboratory	PCC	0	0	4	4	2
			TOTAL	**9**	**1**	**4**	**14**	**12**

SEMESTER IV

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MN3204	Machine Learning for Intelligent Systems	PCC	2	0	2	4	3
2.	MN3203	Quality and Reliability Engineering	PCC	3	0	2	5	4
3.		Professional Elective–V	PEC	3	0	0	3	3
			TOTAL	**8**	**0**	**4**	**12**	**10**

SEMESTER V

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.		Professional Elective–VI	PEC	3	0	0	3	3
2.		Professional Elective–VII	PEC	3	0	0	3	3
PRACTICALS								
2.	MN3311	Project Work – I	EEC	0	0	12	12	6
3.	MN3312	Comprehension	EEC	0	0	2	2	1
			TOTAL	**6**	**0**	**14**	**20**	**13**

SEMESTER VI

S. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		C
PRACTICALS								
1.	MN3411	Project Work –II	EEC	0	0	24	24	12
			TOTAL	**0**	**0**	**24**	**24**	**12**

TOTAL NO. OF CREDITS 14.5+13.5+11+10+10+16= 75

Name of the Programme: M.E MANUFACTURING ENGINEERING(PART TIME)								
Sl. No.	**Subject Area**	**Credits Per Semester**						**Total Credits**
		I	**II**	**III**	**IV**	**V**	**VI**	
1	**MC**	3						**3**
2	**FC**	4						**4**
3	**PCC**	3+1.5	3+3+1.5	4+3+2	3+4			**28**
4	**PEC**	3	3+3	3	3	3+3		**21**
5	**EEC**					6+1	12	**19**
		14.5	**13.5**	**12**	**10**	**13**	**12**	**75**

FOUNDATION COURSES (FC)

S. No.	Course Code	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1.	MN3101	Computational Methods for Manufacturing	3	1	0	4	1
		TOTAL	**3**	**1**	**0**	**4**	

PROFESSIONAL CORE COURSES (PCC)

S. No.	Course Code	Course Title	Periods Per Week			Credits	Semester
			L	T	P		
1.	CI3151	Solid Freeform Manufacturing	3	0	0	3	1
2.	MN3102	Composite Materials Processing	3	0	0	3	1
3.	MN3103	Advanced Machining and Forming Process	3	0	0	3	1
4.	MN3111	Advanced Machining and Forming Laboratory	0	0	3	1.5	1
5.	MN3112	Material Processing Laboratory	0	0	3	1.5	1
6.	MN3201	Finite Element Applications in Manufacturing	3	1	0	4	2
7.	MN3202	Thin Film Technology	3	0	0	3	2
8.	MN3203	Quality and Reliability Engineering	3	0	2	4	2
9.	MN3204	Machine Learning for Intelligent Systems	2	0	2	3	2
10	MN3211	Finite Element Analysis Laboratory	0	0	4	2	2
		TOTAL	**20**	**1**	**14**	**28**	

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO	Course Code	Course Title	Periods per Week			Credits	Semester
			L	T	P		
1.	RM3151	Research Methodology and IPR	2	1	0	3	1
		TOTAL	**2**	**1**	**0**	**3**	

PROFESSIONAL ELECTIVE COURSES (PEC)

ALL COURSES COMMON TO PROFESSIONAL ELECTIVES I-VI

ADVANCED MANUFACTURING

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1	CI3051	Advances in Welding and Casting Technology	PEC	3	0	0	3	3
2	MN3001	Laser Processing of Materials	PEC	3	0	0	3	3
3	MN3002	Manufacturing Systems and Models	PEC	3	0	0	3	3
4	MN3003	Bio-inspired Manufacturing	PEC	3	0	0	3	3
5	CI3053	Micro and Nano Manufacturing	PEC	3	0	0	3	3
Total				**15**	**0**	**0**	**15**	**15**

MATERIALS AND PROCESSING

S. No.	Course Code	Course Title	Category	Periods per Week			Total Contact Periods	Credits
				L	T	P		
THEORY								
1.	MN3004	Smart Materials	PEC	3	0	0	3	3
2.	MN3005	Material Testing and Characterization	PEC	3	0	0	3	3
3.	MN3006	Manufacturing Metrology	PEC	3	0	0	3	3
4.	MN3007	Green Manufacturing	PEC	3	0	0	3	3
5.	MN3008	Powder Processing	PEC	3	0	0	3	3
Total				**15**	**0**	**0**	**15**	**15**

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

MANAGEMENT

S. No.	Course Code	Course Title	Category	Periods per Week L	T	P	Total Contact Periods	Credits
THEORY								
1.	IL3251	Supply Chain Systems And Management	PEC	3	0	0	3	3
2.	QE3251	Lean Six Sigma	PEC	3	0	0	3	3
3.	IL3152	Operations Management	PEC	3	0	0	3	3
4.	QE3051	Quality Management	PEC	3	0	0	3	3
5.	MS3051	Human Resource Management	PEC	3	0	0	3	3
Total				**15**	**0**	**0**	**15**	**15**

DESIGN

S. No.	Course Code	Course Title	Category	Periods per Week L	T	P	Total Contact Periods	Credits
THEORY								
1.	MN3009	Mechanical Behaviour of Materials and their Measurements	PEC	3	0	0	3	3
2.	MN3010	Advanced FEA and CFD	PEC	3	0	0	3	3
3.	CI3052	Design for Manufacturing and Assembly	PEC	3	0	0	3	3
4.	MN3051	Concepts in Product Development	PEC	3	0	0	3	3
5.	MR3051	Multi-Body Dynamics and Control	PEC	3	0	0	3	3
Total				**15**	**0**	**0**	**15**	**15**

AUTOMATION

S. No.	Course Code	Course Title	Category	Periods per Week L	T	P	Total Contact Periods	Credits
THEORY								
1.	MN3052	Mechatronics in Manufacturing	PEC	3	0	0	3	3
2.	MN3011	Factory Automation	PEC	3	0	0	3	3
3.	MR3052	Digital Twin and Industry 5.0	PEC	3	0	0	3	3
4.	MR3251	Industrial Robotics	PEC	3	0	0	3	3
5.	CI3054	System Simulation for Manufacturing Engineers	PEC	3	0	0	3	3
		Total		**15**	**0**	**0**	**15**	**15**

PRODUCT ORIENTED MANUFACTURING

S. No.	Course Code	Course Title	Category	Periods per Week L	T	P	Total Contact Periods	Credits
THEORY								
1.	MN3012	Battery and Hybrid Energy Storage	PEC	3	0	0	3	3
2.	MN3013	Production of Light weight Components	PEC	3	0	0	3	3
3.	MN3014	Production of Medical Products	PEC	3	0	0	3	3
4.	MN3015	Semiconductor Manufacturing	PEC	3	0	0	3	3
5.	MR3053	Drone Technologies	PEC	3	0	0	3	3
		Total		**15**	**0**	**0**	**15**	**15**

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO	Course Code	Course Title	Periods per Week L	T	P	Credits	Semester
1.	MN3311	Project Work – I	0	0	12	6	3
2.	MN3312	Comprehension	0	0	2	1	3
3.	MN3411	Project Work –II	0	0	24	12	4
		TOTAL	**0**	**0**	**38**	**19**	

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

MN3101 COMPUTATIONAL METHODS FOR MANUFACTURING

	L	T	P	C
	3	1	0	4

COURSE OBJECTIVES:

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

1. To enumerate the fundamental knowledge of Integer programming
2. To solve problems using dynamic programming
3. To understand and solve non-linear programming problems
4. To familiarize on factorial design and Taguchi's design of experiments
5. To have knowledge of decision-making tools in manufacturing

UNIT – I INTEGER PROGRAMMING 12

Branch and bound technique – Cutting plane algorithm method - Travelling Salesman Problem – 0/1 Knapsack Problem – Chinese Postman Problem - Vehicle Routing 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 – stagecoach problem.

UNIT – III NONLINEAR PROGRAMMING 12

Types of Nonlinear Programming Problems - One-Variable Unconstrained Optimization - Multivariable Unconstrained Optimization - The Karush-Kuhn-Tucker (KKT) - Quadratic Programming - Separable Programming

UNIT – IV DESIGN OF EXPERIMENTS 12

Fundamentals – fractional, factorial experiments – 2^k factorial design – 3 level and mixed level factorials – Response Surface Methods and Designs, Robust Parameters Design and Process Robustness Studies

UNIT – V DECISION MAKING 12

Fundamentals of Decision Making – Decision Tables – Types of decisionmaking environments – Under certainty, under uncertainty, under risk – Expected Value of Perfect Information – Decision Trees – Poker Decision Process

TOTAL: 60 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Explain the fundamentals of optimization through integer, dynamic and nonlinear programming

CO2 Identify appropriate optimization methods to solve complex problems involved in various industries.

CO3 Explain the methods of implementing design of experiments

CO4 Find appropriate trade-off solutions for multi-objective decision making problems in production systems, supply chain systems and specific operational problems

CO5 Compare the techniques of decision making under different environmental conditions.

REFERENCES:

1. Fredrick S. Hillier and G. J. Liberman, "Introduction to Operations Research", McGraw Hill Inc., 11th edition, 2021.

2. Kalymanoy Deb, "Optimization for Engineering Design", PHI Learning private Ltd., 2nd edition, 2012.
3. Ravindran, Phillips, Solberg, "Operations Research – Principles and Practice", John Wiley India, 2nd edition, 2007.
4. Singiresu S. Rao, "Engineering Optimization – Theory and practices", John Wiley and Sons, 5th edition, 2020.
5. Krishnaiah K, Shahabudeen P, "Applied Design of Experiments and Taguchi Methods", PHI Learning, 2012.
6. Heizer. J, Render. B., "Operations Management", Pearson, 13thEdition,2019.

Mapping of COs with POs

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	-	1	2	1	1.4
CO2	2	1	-	1	2	1	1.4
CO3	2	1	-	1	2	1	1.4
CO4	2	1	1	1	2	2	1.5
CO5	2	1	1	1	2	2	1.5
POs Average	2.0	1.0	1.0	1.0	2.0	1.4	
1 – Slight, 2 – Moderate, 3 - Substantial							

CI3151 **SOLID FREEFORM MANUFACTURING**

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To gain knowledge on evolution of Solid Freeform Manufacturing (SFM) and the importance of DfAM in improving the quality.
2. To acquaint with various SFM Technologies and hybrid processes, along with their material science and applications in different fields.

UNIT I INTRODUCTION 9

Introduction to solid freeform manufacturing (SFM) - Need- SFM evolution, Distinction between SFM & CNC machining- Development of SFM systems — Hierarchical structure of SFM - SFM process chain — Classification. SFM Supply chain - Economics aspect: Strategic aspect- Operative aspect

UNIT II DESIGN FOR ADDITIVE MANUFACTURING (DfAM) 9

Concepts and Objectives- General Guidelines for DfAM - DfAM tools, Requirements of DfAM methods, - Additive Manufacturing (AM) Unique Capabilities –Design Consideration in AM- Part Consolidation – Computational tools for design analysis- Topology Optimization - Lightweight Structures – Generative design- DfAM for Part Quality Improvement - CAD Modeling - Model Reconstruction - Data Processing for AM - Data Formats: STL, AMF,PLY, VRML- Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation.

UNIT III VAT POLYMERIZATION, MATERIAL EXTRUSION & SHEET LAMINATION TECHNOLOGIES 9

Vat polymerization: Stereolithography Apparatus (SLA): Principles — Photo Polymerization of SL Resins - Pre Build Process — Part-Building and Post-Build Processes - Part Quality and Process Planning, Recoating Issues - Materials - Capabilities - Limitations and Applications. Digital Light Processing (DLP) - Materials - Process – Capabilities and Applications. Continuous Liquid Interface Production (CLIP)- Materials - Process - Capabilities and Applications. Material extrusion: Fused deposition Modeling (FDM): Working Principles - Process - Materials – Capabilities and Applications. Design Rules for FDM. Sheet lamination processes: Laminated Object Manufacturing (LOM): Working Principles - Process – Materials- Capabilities- Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters –Capabilities- Applications. Case Studies.

UNIT IV POWDER BED FUSION, BINDER JETTING, MATERIAL JETTING & DIRECT ENERGY DEPOSITION TECHNOLOGIES 9

Powder Bed Fusion: Selective Laser Sintering (SLS): Principles - Process - Indirect and Direct SLS - Powder Structure -Materials - Surface Deviation and Accuracy – Capabilities- Applications. Multijet Fusion Principles – Processes - Materials — Capabilities and Applications. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles — Processes — Materials — Capabilities - Limitations and Applications. Binder Jetting: Three dimensional Printing (3DP): Principles - Process - Physics of 3DP - Process — Materials - Capabilities - Limitations - Applications. Material Jetting: Multi Jet Modelling (MJM) - Principles - Process - Materials - Capabilities and Application. Direct Energy Deposition: Laser Engineered Net Shaping (LENS): Processes- Materials- Capabilities - Limitations and Applications. Hybrid Additive Manufacturing – Need - Principles - Part Quality and Process Efficiency. Wire Arc Additive Manufacturing (WAAM) Processes- Materials- Capabilities - Limitations and Applications. Case Studies.

UNIT V MATERIALS AND APPLICATIONS OF SFM 9

Materials science for SFM - Multifunctional and graded materials in AM, Role of solidification rate, Evolution of non-equilibrium structure, microstructural studies, Structure property relationship. Application of SFM in Automotive-Aerospace-Bio Medical-Bio printing- Food Printing- Electronics printing — Rapid Tooling - Building printing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to

CO 1: Explore the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain

CO 2: Recognize the importance of DfAM in improving the quality of fabricated parts and understand the guidelines of DfAM

CO 3: Acquire knowledge on principles and applications of vat polymerization, material extrusion and sheet lamination processes with case studies.

CO 4: Acquire knowledge on principles of powder bed fusion, jetting, direct energy deposition and hybrid processes

CO 5: Understand the properties and characteristics of materials used in SFM/AM and explore the applications in various fields.

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	2	2	1	2	2
CO2	3	3	2	2	2	3
CO3	3	2	3	3	3	2
CO4	3	3	2	3	3	2
CO5	3	2	3	2	3	3

REFERENCES:

1. Ian Gibson, David W. Rosen and Brent Stucker, “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing” Springer - New York, USA, 3rd Edition, 2021. ISBN- 978- 3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hotter, “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications Munchen, Germany, 2016. ISBN: 978-1-56990-582-1.
3. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
4. Liou, L.W. and Liou, F.W., “Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 1°t Edition, 2019 FL, USA. ISBN-9780429029721
5. Ben Redwood, Brian Garret, FilemonSchoffer, and Tony Fadel, “The 3D Printing Handbook: Technologies, Design and Applications”, 3D Hubs B.V., Netherland, 2017. ISBN-13: 978- 9082748505.
6. Milan Brandt., “Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications”, Woodhead Publishing, UK, 2016. ISBN-9780081004333.

MN3102 COMPOSITE MATERIALS PROCESSING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students
1. To learn the analysis and fabrication methods of polymer matrix composites.
2. To study the processing methods of metal matrix composite and its applications.
3. To learn the processing methods of ceramic matrix composite with their properties.
4. To introduce to mechanics of composites.
5. To familiarize on advanced materials and its processing.

UNIT – I PROCESSING OF POLYMER COMPOSITES 9

Introduction to composites, fibers, matrix. Preparation of moulding compounds and Prepregs – hand layup method – Spray technique – Autoclave method – Filament winding method – Compression moulding – pultrusion – Reaction injection moulding – Resin Transfer moulding (RTM) – bag moulding. Thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, and injection moulding. Mechanical properties of composites – Rule of Mixtures – Recycling of composites.

UNIT – II MANUFACTURING OF METAL MATRIX COMPOSITES 9

Metallic matrices: aluminium, titanium, magnesium, copper alloys – Manufacturing of Metal Matrix Composites: Solid state – Casting – Solid state diffusion technique – Cladding – Hot isostatic pressing – Properties and applications, liquid state, vapour state processing, in situ fabrication techniques – diffusion bonding – powder metallurgy techniques interfaces in MMCs – mechanical properties – machining of MMCs – Applications.

UNIT– III FABRICATION AND TESTING OF CERAMIC COMPOSITES 9

Processing of CMCs: cold pressing, sintering, reaction bonding, liquid infiltration, Lanxide process, chemical vapour deposition, chemical vapour impregnation, and sol-gel – interfaces in CMCs – mechanical properties and applications of CMCs – Carbon-carbon Composites applications. Thermal properties of composites – Thermal expansion – Specific heat – Phase transformations – Thermal conductivity – Thermal conductance of an Interface – Evaluating the thermal conduction – uses. Testing of composites: Mechanical testing of composites, tensile testing, compressive testing, Intra-laminar shear testing, Inter-laminar shear testing, Fracture testing.

UNIT– IV MECHANICS OF COMPOSITES 9

Analysis of macro and micro mechanics of a lamina. Generalized Hooke's Law and its application to composite laminates, Reduction to a homogeneous orthotropic lamina and its relation to the isotropic limit case, Definition of stress and moment resultants in a lamina - Laminate Constitutive Equations, Basic assumptions of laminated anisotropic plates, Derivation and formulation of laminate constitutive equations, Laminate structural moduli and their determination - Laminate Stress Analysis and Failure Criteria, Determination of lamina stresses within laminates, Von-Mises yield criterion for isotropic materials and its application to composites, Generalized Hill's criterion for anisotropic materials and its significance, Tsai-Hill's failure criterion for composites and its interpretation, Tensor polynomial (Tsai-Wu) failure criterion and its applications.

UNIT – V ADVANCED MATERIALS AND PROCESSING 9

Fundamental Manufacturing and properties of High entropy alloys – bulk metallic glass – glassy and amorphous materials– Auxetic structures – negative Poisson structure. Fabrication of shape memory materials structures/ products- High temperature materials – superalloys-lightweight structure – porous metal structure- Introduction to energy storage materials-batteries – hydrogen storage. Attested

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Define composites, fibers, and matrix materials used in polymer composites.

CO2 Explain the various manufacturing processes involved in the production of metal matrix composites

CO3 Design a novel method or modification to enhance the interfacial bonding and mechanical properties of ceramic matrix composites.

CO4 Evaluate the laminate structural module and their significance in predicting the mechanical response of composite laminates.

CO5 Develop and optimize manufacturing processes for high entropy alloys, bulk metallic glasses, and amorphous materials to achieve desired properties and microstructures.

REFERENCES:

1. Krishnan K Chawla, “Composite Materials: Science and Engineering”, 4th edition, Springer, 2021.
2. MallickP.K., “Fiber Reinforced Composites: Materials, Manufacturing and Design”, CRC press, New Delhi, 3rd edition, 2008.
3. I.J. Polmear, “Light Alloys- From Traditional alloys to Nanocrystals”, 4th Edition, Elsevier Publication, 2006.
4. Said Jahanmir, Ramulu M. and Philp Koshy, “Machining of Ceramics and Composites”, Marcel Dekker Inc., New York, 1999.
5. I. M. Daniel, O. Ishai, “Engineering Mechanics of Composite Materials”, Oxford University Press, Second Edition, 2007.
6. Clyne, T. W. and Withers, P. J., “Introduction to Metal Matrix Composites”, Cambridge University Press, 2010.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	1	1	2	1	1	1.2
CO2	1	1	1	2	1	2	1.3
CO3	1	1	1	2	1	1	1.2
CO4	2	1	1	2	1	2	1.5
CO5	1	1	1	2	1	2	1.3
POs Average	1.2	1.0	1.0	2.0	1.0	1.6	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3103	ADVANCED MACHINING AND FORMING PROCESS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. Comprehend the characteristics and selection of high-speed cutting tools and tool materials
2. Recall the concept of precision machining and its importance in machining hard and brittle materials.
3. Evaluate future trends and challenges in the machining of difficult-to-machine materials and propose strategies for enhancing machining efficiency and quality.
4. Analyze industry case studies to understand the practical applications and challenges in modern metal forming
5. Comprehend the material selection and behavior in advanced bulk forming processes and the importance of surface treatments and coatings.

UNIT – I HIGH-SPEED MACHINING METHODS 9

Principles and Fundamentals of High-Speed Machining - High-Speed Cutting Tools and Tool Materials - High-Speed Machining Techniques - Trochoidal Milling - Adaptive Milling - High-Speed Drilling - High-Speed Turning - High-Speed Wire EDM - High-Speed Laser Machining - High-Speed Abrasive Waterjet Cutting- Industry case studies, Future trends and challenges in high-speed machining.

UNIT – II PRECISION MACHINING 9

Introduction - Ductile mode machining of hard and brittle materials - Ultra precision grinding and selection of grinding wheels - Electrolytic in process dressing -Chemical mechanical polishing -Diamond turn machining - High speed machining -Magneto rheological finishing processes - Industry case studies, Future trends and challenges in precision machining.

UNIT– III MACHINING OF DIFFICULT-TO-MACHINE MATERIALS 9

Overview - high-strength alloys, hardened steels, superalloys, composites, etc. - Challenges and characteristics - Importance and applications - Tool materials - Coatings and surface treatments for improved tool life and performance - Analysis of cutting forces, heat generation, and chip formation - Industry case studies, Future trends and challenges in machining of difficult-to-machine materials.

UNIT – IV MODERN METAL FORMING 9

Introduction - different methods, Tooling design and process parameters and Advantages, limitations - Incremental Sheet Forming - Superplastic Forming - High-Speed Forming – Micro forming -Multi-Scale Forming – Electromagnetic Forming – Electrohydraulic Forming -Powder forming: Powder rolling, Powder extrusion - High speed extrusion - Industry case studies, Future trends and challenges in advanced metal forming.

UNIT – V ADVANCED BULK FORMING 9

Introduction - different types, Equipment and tooling considerations, Material selection and behaviour, Process parameters and control - Surface treatments and coatings - Hot Forging and Warm Forging - Precision Forging - Roll Forming - Profile Extrusion - Hybrid Bulk Forming - Industry case studies, Future trends and challenges in advanced bulk forming.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Apply advanced machining methods such as high-speed cutting, trochoidal milling, and adaptive milling to achieve efficient and precise machining operations

CO2 Utilize precision machining techniques including ultra-precision grinding, electrolytic in-process dressing, and diamond turn machining to achieve high-quality surface finishes and dimensional accuracy.

CO3 Develop the ability to machine difficult-to-machine materials, such as high-strength alloys and composites, by selecting suitable tool materials, coatings, and machining parameters

CO4 Apply modern metal forming processes, such as incremental sheet forming and superplastic forming, to produce complex shapes with improved material utilization and dimensional accuracy.

CO5 Evaluate and analyze industry case studies to understand the practical applications, challenges, and future trends in advanced machining and metal forming processes and propose innovative solutions to address these challenges.

REFERENCES:

1. Robert King , “Handbook of High-Speed Machining” ,springer, Third edition , 2014
2. Jain V.K., “Introduction to Micromachining”, Narosa, New Delhi, 2nd edition, 2019.
3. Kalpakjian S., and Schmid S.R., “Manufacturing Processes for Engineering Materials”,Pearson, New Delhi, 6th edition, 2023.
4. Venkatesh V. C. and SudinIzman, “Precision Engineering”, Tata McGraw-Hill, NewDelhi, 2008.
5. William F. Hosford and Robert M. Caddell, “Metal Forming: Mechanics and Metallurgy”, Cambridge university press , Fourth Edition, 2014.
6. Taylan Altan, Gracious Ngaile, and Gangshu Shen, “Metal Forming: Fundamentals and Applications”, American Society for Metals, 2011.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	2	2	2	2	2	2.0
CO2	2	2	2	2	2	2	2.0
CO3	2	2	2	2	2	2	2.0
CO4	2	2	2	2	2	1	1.8
CO5	2	2	2	2	2	1	1.8
POs Average	2.0	2.0	2.0	2.0	2.0	1.6	

1 – Slight, 2 – Moderate, 3 - Substantial

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

RM3151 **RESEARCH METHODOLOGY AND IPR** **L T P C**
2 1 0 3

OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9 Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9 Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, the student can

CO1: Describe different types of research; identify, review and define the research problem
CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
CO3: Explain the process of data analysis; interpret and present the result in suitable form
CO4: Explain about Intellectual property rights, types and procedures
CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, “Business Research Methods”, Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, “Research methodology for natural sciences”, IISc Press, Kolkata, 2022,
3. Catherine J. Holland, “Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets”, Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, “Patent searching: tools & techniques”, Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, “Professional Programme Intellectual Property Rights, Law and practice”, September 2013.

MN3111	ADVANCED MACHINING AND FORMING LABORATORY	L	T	P	C
		0	0	3	1.5

OBJECTIVES:

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

1. Analyze and evaluate the effects of different machining parameters on the quality of machined components, such as dimensional accuracy and surface finish
2. Apply appropriate techniques and instruments to measure and analyze surface roughness of machined components, demonstrating proficiency in using surface roughness testers or profilometers.
3. Evaluate the quality, dimensional accuracy, and mechanical properties of the printed parts and propose improvements

LIST OF EXERCISES

1. CNC Machining Experiment: Perform a machining operation using a CNC (Computer Numerical Control) machine, such as milling or turning.
2. Surface Roughness Measurement: Measure the surface roughness of machined components using instruments like a profilometer or surface roughness tester.
3. Tool Wear Analysis: Analyze the wear characteristics of cutting tools used in machining operations.
4. Metal Forming Experiment: Perform a metal forming operation, such as bending, deep drawing, incremental forming and superplastic forming.
5. EDM (Electrical Discharge Machining) and WEDM (Wire Electrical Discharge Machining: Perform EDM experiments to understand the principles of material removal through electrical discharges.
6. Additive Manufacturing: Explore additive manufacturing processes using 3D printing machines.
7. Laser engraving process
8. Cutting of different materials during water jet machining
9. Experiments on Ultrasonic Machining
10. Experiments on hydroforming
11. Micro hole drilling in ECM
12. Experiments on incremental forming

(Any 10 for Conduct of end semester examination)

TOTAL = 45 PERIODS

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1 Demonstrate a high level of competence in operating CNC machines, including programming, tool selection, and machining parameter optimization. They will be able to produce accurate and precise machined components

CO2 Acquire the skills to accurately measure and analyze surface roughness using appropriate instruments. They will be able to assess and interpret surface roughness data to ensure the desired quality of machined surfaces.

CO3 Interpret the tool wear characteristics in machining operations. They will be able to analyze tool wear patterns, measure tool wear parameters, and propose effective strategies to minimize tool wear and prolong tool life.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	2	2	2	2	1	2.0
CO2	3	2	2	2	2	1	2.0
CO3	3	2	2	2	2	1	2.0
POs Average	3.0	2.0	2.0	2.0	2.0	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3112 MATERIAL PROCESSING LABORATORY

	L	T	P	C
	0	0	3	1.5

OBJECTIVES:

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

1. To understand various Mechanical, Chemical, Thermal and Electrical based modern materials processing techniques through practical skill sets.
2. To analyse and observe the principles and its importance
3. To study the major applications in manufacture

LIST OF EXERCISES

1. Ultrasonic cavitations –stir casting –metal matrix composite.
2. Squeeze casting.
3. Mechano-chemical synthesis of materials using a high energy ball mill.
4. Microwave sintering of powder compacts, Testing of sintered – micro Vicker – fracture toughness estimation.
5. Chemical vapour deposition of coating.
6. Hand layup method – Laminate fabrication.
7. Compression moulding for the preparation of laminated composites and its testing – flexural – interlaminar - fracture mode analysis.
8. Sandwich structure fabrication metallic foam fabrication.
9. Injection moulding of a bush (typical component)
10. Additive manufacturing using FDM.
11. Pin on Disc - wear measurement.

(Any 10 for Conduct of end semester examination)

TOTAL = 45 PERIODS

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1 Understand and grasp the significance of modern materials processing and its applications through hands-on experience

CO2 Identify the selection of materials processes and its process parameters

CO3 Express and perform project related works.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	2	2	2	2	1	2.0
CO2	3	2	2	2	2	1	2.0
CO3	3	2	2	2	2	1	2.0
POs Average	3.0	2.0	2.0	2.0	2.0	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3201	FINITE ELEMENT APPLICATIONS IN MANUFACTURING	L	T	P	C
		0	1	0	4

COURSE OBJECTIVES:

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

1. Understand and apply mathematical models for one-dimensional problems and employ numerical methods to solve them effectively.
2. Analyze and solve two-dimensional scalar and vector variable problems to determine field variables, using appropriate mathematical techniques.
3. Apply iso-parametric transformation and numerical integration methods to accurately evaluate element matrices in finite element analysis
4. Utilize various solution techniques to effectively solve eigenvalue problems encountered in finite element analysis.
5. Demonstrate knowledge of key factors, pre-processing and post-processing steps, and the utilization of computer tools in the implementation of finite element analysis.

UNIT – I INTRODUCTION 12

Historical Background – Weighted Residual Methods - Basic Concept of FEM – Variational Formulation of B.V.P. – Ritz Method – Finite Element Modelling – Element Equations – Linear and Higher order Shape functions – Bar, Beam Elements –Applications to Heat Transfer problems.

UNIT – II FINITE ELEMENT ANALYSIS OF TWO-DIMENSIONAL PROBLEMS 12

Basic Boundary Value Problems in two-dimensions – Linear and higher order Triangular, quadrilateral elements – Poisson's and Laplace's Equation – Weak Formulation – Element Matrices and Vectors – Application to scalar variable problems - Introduction to Theory of Elasticity – Plane Stress – Plane Strain and Axisymmetric Formulation – Principle of virtual work– Element matrices using energy approach.

UNIT– III ISO-PARAMETRIC FORMULATION 12

Natural Coordinate Systems – Lagrangian Interpolation Polynomials – Iso-parametric Elements –Formulation – Shape functions -one dimensional, two dimensional triangular and quadrilateral elements -Serendipity elements- Jacobian transformation - Numerical Integration – Gauss quadrature – one-, two- and three-point integration.

UNIT – IV EIGENVALUE PROBLEMS 12

Dynamic Analysis – Equations of Motion – Consistent and lumped mass matrices – Free Vibration analysis – Natural frequencies of Longitudinal, Transverse and torsional vibration –Solution of Eigenvalue problems - Introduction to transient field problems.

UNIT – V COMPUTER IMPLEMENTATION AND FE ANALYSIS 12

Pre Processing, mesh generation, elements connecting, boundary conditions, input of material and processing characteristics – Solution and post processing – Overview of application packages – Development of code for one dimensional analysis and validation - FE analysis of metal casting – special considerations, latent heat incorporation, gap element –Time stepping procedures – Crank – Nicholson algorithm – Prediction of grain structure – Basic concepts of plasticity and fracture – Solid and flow formulation – small incremental deformation formulation – Fracture criteria – FE analysis of metal cutting, chip separation criteria, incorporation of strain rate dependency – FE analysis of welding.

TOTAL: 60 PERIODS

Attested

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Apply mathematical models and numerical methods to solve one-dimensional problems, demonstrating proficiency in analyzing and solving engineering problems.

CO2 Analyze and solve two-dimensional scalar and vector variable problems using appropriate mathematical techniques, showcasing the ability to determine field variables accurately

CO3 Apply iso-parametric transformation and numerical integration methods to evaluate element matrices in finite element analysis, demonstrating competence in handling complex structural and mechanical systems.

CO4 Utilize various solution techniques to effectively solve eigenvalue problems encountered in finite element analysis, showcasing the ability to determine natural frequencies and modes of vibration.

CO5 Compare proficiency in utilizing finite element methods and computer tools for modeling, analysis, and simulation in manufacturing processes, highlighting the ability to tackle real-world engineering challenges.

REFERENCES:

1. Amar Khennane, “Introduction to Finite Element Analysis using MATLAB and Abaqus”, CRC Press, 1stEdition, 2013.
2. Kobayashi S, Soo-ik-Oh and Altan T, “Metal Forming and the Finite Element Methods”, Oxford University Press, 4th Edition,1989.
3. Lewis R.W. Morgan K, Thomas H.R and Seetharaman K.N, “The Finite Element Method in Heat Transfer Analysis”, John Wiley, 1stEdition, 1996.
4. Rao S.S, “Finite Element method in engineering”, Butterworth-Heinemann, 6th Edition, 2018.
5. Reddy J.N, “An Introduction to the Finite Element Method”, McGraw Hill, Fourth Edition ,2020.
6. Seshu P, “Textbook of Finite Element Analysis”, PHI Learning Pvt. Ltd, 2014.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	2	2	2	2	2.0
CO2	3	2	2	2	2	2	2.2
CO3	3	2	2	2	2	2	2.2
CO4	3	2	2	2	2	2	2.2
CO5	3	2	3	3	3	2	2.7
POs Average	3.0	1.8	2.2	2.2	2.2	2.0	

1 – Slight, 2 – Moderate, 3 – Substantial

MN3202 **THIN FILM TECHNOLOGY** **L T P C**

3	0	0	3

COURSE OBJECTIVES:

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

1. Acquiring a comprehensive knowledge on the basics of thin films technology
2. Introduce various types of physical vapour deposition techniques for thin film
3. Introduce various types of chemical vapour deposition techniques for thin film
4. Means to control and monitor thin film and properties of thin film.
5. Applications of thin films in various fields.

UNIT – I INTRODUCTION TO THIN FILMS AND VACUUM TECHNOLOGY 9

Definition of thin films - Formation of thin films (sticking coefficient, formation of thermodynamically stable cluster - nucleation) - Environment (Gas phase and plasma) for thin film deposition; Deposition parameters and their effects on film growth, Substrates – overview of various substrates utilized - Concept of different vacuum pumps: rotary, diffusion, Turbo molecular pump, Cryogenic-pump, Ti-sublimation pump, Concept of different gauges: Pirani, penning, Pressure Control – Mass flow controllers.

UNIT – II PHYSICAL VAPOUR DEPOSITION (PVD) TECHNIQUES 9

Evaporation- Thermal evaporation, Electron beam evaporation; Laser ablation; Ion beam evaporation and Cathodic arc deposition, Molecular Beam Epitaxy. Glow discharge Sputtering- DC and RF Sputtering; Magnetron sputtering; Ion beam sputtering – Reactive sputtering. Nucleation and growth of thin films (qualitative study only): Four stages of film growth.

UNIT– III CHEMICAL VAPOUR DEPOSITION (CVD) TECHNIQUES 9

Advantages and disadvantages of Chemical vapour deposition (CVD) techniques over PVD techniques, Different kinds of CVD techniques: Metallo Organic (MO) CVD, thermally activated CVD, Plasma enhanced CVD, Atomic layer deposition (ALD)- Importance of ALD technique. Epitaxy – Introduction: Epitaxial growth- Growth kinetics of epitaxy, Growth modes – illustration of crystallographic relations with thin film to substrate, characterization of epilayers (in situ and ex situ)

UNIT – IV DEPOSITION MONITORING, CONTROL AND PROPERTIES OF THIN FILM 9

Microbalance, Crystal oscillator thickness monitor, optical monitor, Resistance Monitor. Thickness measurement: Multiple Beam Interferometer, Fizeau (Tolansky) technique - Fringes of equal chromatic order (FECO) method - Ellipsometry (qualitative only). Sheet resistance - size effect - Electrical conduction in thin metallic films. Effect of Ageing and Annealing - Oxidation - agglomeration. Dielectric properties: DC conduction mechanism - Low field and high field conduction. Breakdown mechanism in dielectric films - AC conduction mechanism. Temperature dependence of conductivity. Optical properties: Optical constants and their determination - Spectrophotometer method. Anti-reflection coatings. Interference filters. Thin film Solar Cells $CuInSe_2$ solar cell

UNIT – V APPLICATION OF THIN FILMS 9

Thin film resistors: Materials and Design of thin film resistors (Choice of resistor and shape and area) - Trimming of thin film resistors - sheet resistance control - Individual resistor trimming. Thin film capacitors: Materials - Capacitor structures - Capacitor yield and capacitor stability. Thin film field effect transistors: Fabrication and characteristics - thin film diodes.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Explain the fundamentals of thin film technology.

CO2 Compare the various PVD techniques of preparation of thin films

CO3 Compare the various CVD techniques of preparation of thin films and epitaxial growth

CO4 Explain the process of deposition monitoring and its film growth as well as unique properties of thin film.

CO5 List the thin film application in various fields of engineering

REFERENCES:

1. Goswami A, “Thin Film Fundamentals”, New Age International (P) Ltd., 2006.
2. K. L. Chopra, “Thin Film Phenomena”, McGraw-Hill, 1985.
3. AichaElshabini - Riadaud Fred D Barlow III, “Thin Film Technology Hand book”, McGraw Hill Company, 1998.
4. Anders H, “Thin Films in Optics”, Focal press, 1973.
5. Guthrie A, “Vacuum Technology”, Krieger, Malabar, 1990.
6. MaisselL.I and Glang R, “Handbook of Thin Film Technology”, McGraw Hill, 1970.
7. Rao V. V, Ghosh, T. B, Chopra, K. L, “Vacuum Science and Technology”, Allied Publications, 1998.
8. Schwartz B and Schwartz N, “Measurement Techniques for Thin Films”, John Wiley & Sons, 1968.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	2	1	1	1	1.5
CO2	2	2	2	2	2	1	1.8
CO3	2	1	2	2	2	1	1.7
CO4	1	1	2	2	2	2	1.7
CO5	1	2	1	1	1	2	1.3
POs Average	1.8	1.4	1.8	1.6	1.6	1.4	

1 – Slight, 2 – Moderate, 3 – Substantial

MN3203 QUALITY AND RELIABILITY ENGINEERING

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

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

1. To study the approaches and techniques to assess quality by statistical process control.
2. To study the methodology to assess and sampling of parameters
3. To Impart knowledge in reliability concepts and assess the various configurations
4. To Impart knowledge in reliability monitoring methods
5. To analyze effectively various techniques to improve reliability of the system.

UNIT – I QUALITY AND STATISTICAL PROCESS CONTROL 9

Quality – Definition – Quality Assurance – Variation in process – Factors – process capability –control charts – variables X, R and X, - Attributes P, C and U-Chart tolerance design. Establishing and interpreting control charts – charts for variables – Quality rating – Short run SPC

UNIT – II ACCEPTANCE SAMPLING 9

Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling plans – OC curves – Producer ‘s risk and consumer ‘s risk. AQL, LTPD, AOQL, Concepts – standard sampling plans for AQL and LTPD – use of standard sampling plans

UNIT– III RELIABILITY CONCEPTS AND ASSESSMENT 9

Reliability definition – Reliability mathematics – Reliability functions – Hazard rate – Measures of Reliability – Design life –A priori and posteriori probabilities – Mortality of a component – Mortality curve – Useful life-Different configurations – Redundancy – k out of n system – Complex systems: RBD – Baye’s approach – Cut and tie sets – Fault Trees – Standby systems.

UNIT – IV RELIABILITY MONITORING 9

Life testing methods: Failure terminated – Time terminated – Sequential Testing –Reliability growth monitoring – Reliability allocation – Software reliability-Human reliability.

UNIT – V RELIABILITY IMPROVEMENT 9

Analysis of downtime – Repair time distribution – System repair time – Maintainability prediction – Measures of maintainability – Inspection decisions –System Availability.

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Apply quality principles, process variation, and control charts for effective quality management.
CO2 Discuss different sampling plans.
CO3 Explain reliability concepts and assess the various configurations.
CO4 Build knowledge in reliability monitoring methods.
CO5 Examine effectively various techniques to improve reliability of the system.

REFERENCES:

1. AmitavaMitra, “Fundamentals of Quality Control and Improvement”, Pearson Education, 5th Edition, 2021.
2. Charles E Ebling, “An Introduction to Reliability and Maintainability Engineering”, Tata-McGraw Hill, Third Edition, 2019.
3. David J Smith, “Reliability, Maintainability and Risk: Practical Methods for Engineers”, Butterworth, Tenth Edition, 2022.
4. Dhillon, “Engineering Maintainability – How to design for reliability and easy maintenance”, PHI, 2008.
5. Patrick D T O’Connor, Andre Kleyner, “Practical Reliability Engineering”, John-Wiley and Sons Inc, 5th edition ,2015.
6. Roy Billington and Ronald N. Allan, “Reliability Evaluation of Engineering Systems”, Springer, 2007.

QUALITY SYSTEMS LABORATORY

LIST OF EXERCISES
1. One-way ANOVA and Two-way ANOVA testing
2. Linear Regression and Multiple Regression
3. Full Factorial Design of Experiments
4. Fractional Factorial Design of Experiments
5. Response Surface Methodology analysis
6. Multiple response Optimization
7. Taguchi Methodology

TOTAL = 60 PERIODS

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	2	1	2	2	1	1.7
CO2	2	2	1	2	2	2	1.8
CO3	2	2	1	1	2	2	1.7
CO4	2	2	1	2	2	2	1.8
CO5	2	2	1	2	2	3	2.0
POs Average	2.0	2.0	1.0	1.8	2.0	2.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3204 MACHINE LEARNING FOR INTELLIGENT SYSTEMS

L	T	P	C
2	0	2	3

COURSE OBJECTIVES:

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

1. To introduce basic of machine learning techniques
2. To learn about classification methods
3. To familiarize about clustering methods
4. To summarize the basics of neural networks
5. To impart knowledge on Deep learning and Reinforcement learning.

UNIT – I INTRODUCTION TO MACHINE LEARNING 6

Learning – Types of Machine Learning, Classifications vs Regression, Evaluation metrics and loss functions in Classification, Linear Regression, Evaluation metrics and loss functions in Regression, Applications of AI in Robotics.

UNIT – II CLASSIFICATION METHODS 6

Support Vector Machine Algorithm, Learning with Trees-Using Decision trees-Constructing Decision Trees-Classification example-Decision by committee: Ensemble Learning-Boosting-Bagging-Random Forests.

UNIT – III CLUSTERING 6

Introduction to clustering, Types of Clustering, Agglomerative clustering, K-means clustering, K-means clustering application study, Principal component analysis (PCA), PCA Application case study in Feature Selection for Robot Guidance.

UNIT – IV NEURAL NETWORKS 6

Neural Networks – Perceptron, The Multi-Layer Perceptron – Back Propagation of Error-Multi-layer Perceptron in Practice – Deriving Backpropagation –Application Case Study of Neural Networks in Robotics.

UNIT – V DEEP LEARNING AND REINFORCEMENT LEARNING 6

Deep learning introduction – CNN – RNN, Reinforcement learning, Examples for reinforcement learning, Markov decision process, Major components of RL, Application Case Study of reinforcement learning in Robotics.

TOTAL: 30 PERIODS

Lab Experiments:

1. Basic programs in python
2. Implementation of Linear regression
3. Implementation of SVM model
4. Implementation of Decision tree model
5. Implementation of K-means clustering algorithm
6. Implementation of MLP model
7. Implementation of CNN model
8. Implementation of Q-Learning algorithm

TOTAL: 30 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Understand the basics of machine learning techniques.
CO2 Able to classify the various methods.
CO3 Understand the various clustering methods.
CO4 Build about the basics of neural networks.
CO5 Understand about deep learning and reinforcement learning.

REFERENCES:

1. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, Second Edition, 2023.
2. Tom M Mitchell, "Machine Learning", McGraw Hill Education, 2021.
3. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, First Edition, 2017.
4. Jason Bell, "Machine learning – Hands on for Developers and Technical Professionals", Wiley , First Edition, 2020.
5. EthemAlpaydin, "Introduction to Machine Learning", Adaptive Computation and Machine Learning Series, MIT Press, 4 th Edition, 2020.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	2	2	2	2	1.8
CO2	2	1	1	1	1	1	1.2
CO3	2	1	1	1	1	1	1.2
CO4	2	2	3	2	2	3	2.3
CO5	2	2	3	2	2	3	2.3
POs Average	2.0	1.4	2.0	1.6	1.6	2.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3211 FINITE ELEMENT ANALYSIS LABORATORY **L T P C**
0 0 4 2

OBJECTIVES

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

1. Apply the principles of finite element analysis to design and analyze elements used in manufacturing processes, demonstrating proficiency in utilizing finite element techniques for engineering design.
2. Develop skills in the application of finite element analysis for designing and evaluating manufacturing components, structures, and systems, including the ability to design and optimize elements through numerical simulations.
3. Evaluate and interpret the results obtained from finite element analysis simulations, critically analyzing the performance and behavior of manufacturing systems, and making informed decisions based on the simulation outcomes.

LIST OF EXERCISES

1. One Dimensional FEA Problem like beam, Truss etc.
2. Two Dimensional FEA Problems like plane stress, plane strain, axisymmetric and vibration.
3. Three Dimensional FEA Problems like shell and contact.
4. FEA Application in metal forming like superplastic forming, deep drawing etc
5. FEA Application in Metal cutting
6. FEA Application in casting process
7. 3D Modelling and Assemble of Engine
8. Modelling of Crack Shaft
9. Modelling of Connecting Rod
10. Modelling of Cotter Joint
11. Modelling of Plummer Block and Coupling

(Any 10 for Conduct of end semester examination)

TOTAL = 60 PERIODS

COURSE OUTCOMES

Upon completion of this course, the students will be able to

CO1 Apply the principles of Finite Element Analysis to solve complex problems encountered in the field of production engineering

CO2 Design and analyze manufacturing problems using Finite Element Analysis, to optimize designs and improve manufacturing processes.

CO3 Identify and assess engineering problems in the manufacturing domain and simulate them using Finite Element Analysis, demonstrating the ability to model real-world scenarios and predict their behavior.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	2	2	2	2	2	2.2
CO2	2	3	2	2	2	2	2.2
CO3	3	2	2	3	3	2	2.5
POs Average	2.7	2.3	2.0	2.3	2.3	2.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3311 PROJECT WORK – I **L T P C**

0 0 12 6

COURSE OBJECTIVES:

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

1. To enable students to select and define a problem/need for analysis in the field of manufacturing engineering.
2. To review and analyse literature/ data of selected problems for study and propose objective and scope of project work.
3. To develop hypothesis and identify methodology based on ethical, scientific and systematic application of knowledge in the field of problem.
4. To design, model and experiment/develop optimal solution for problem being investigated
5. To analyse and interpret data, and synthesis of the information to provide valid conclusions and submit project.

EVALUATION:

- A project topic may be selected based on the literature survey and the creative ideas of the students themselves in consultation with their project supervisor. The topic should be chosen so that it will improve and develop the skills to design, fabricate, analyse, test and research. Literature survey and a part of the project work be carried out in project I.
- The project work is evaluated jointly by external and internal examiners constituted by the Head of the Department based on oral presentation and the project report.
- A project report for project I is to be submitted at the end.
- Project work evaluation is based on the Regulations of the Credit system for the Post graduate programmes of Anna University

COURSE OUTCOMES:

Upon completion of this project, the students will be able to

CO1 Apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to the students to be creative and get trained in planning, organising and coordinating various components of project work.

CO2 Design, model and experiment/develop optimal solutions for problems being investigated.

CO3 Analyse and interpret the experimental data from various machining methods and synthesis of the information to provide valid conclusions and submit reports.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	2	2	2	3	2	2.3
CO2	3	2	2	2	3	2	2.3
CO3	3	2	2	3	3	3	2.7
POs Average	3.0	2.0	2.0	2.3	3.0	2.3	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3312 COMPREHENSION L T P C

0	0	2	1

COURSE OBJECTIVES:

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

1. To correlate the concepts and principles of various domain of knowledge
2. To interpret and analyze typical problems, case studies etc.
3. To evaluate, review and comprehensively propose the solution to the questions.

EVALUATION:

The students shall be evaluated by written and/or oral examination on selected topics spread across the semester and reviewed by a three-member committee approved by the Head of the Department. The topics shall cover fundamental concepts of manufacturing techniques, management principles and techniques, basics materials processing and behaviour, analysis and testing etc.

TOTAL = 30 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to

CO1 Summarise logically the problem by comprehending various domain of knowledge

CO2 Examine typical problems, case studies etc. and identify relationship between various components/concepts

CO3 Justify a solution for a question on the basis of comprehensive review and evaluation of various alternatives.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	2	1	2	1	1.7
CO2	3	1	2	1	2	1	1.7
CO3	3	1	2	1	2	1	1.7
POs Average	3.0	1.0	2.0	1.0	2.0	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3411 PROJECT WORK – II

L	T	P	C
0	0	24	12

COURSE OBJECTIVES:

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

1. To propose and define a problem/need for analysis in the field of manufacturing engineering based on practical experience in project-I work.
2. To comprehensively review and analyse literature/ data to develop hypothesis and identify methodology based on ethical, scientific and systematic application of knowledge in the field of problem.
3. To design experiments, develop models and conduct experiments/ simulations for development of sustainable and economical solutions for problem being investigated.
4. To analyse and interpret data, and synthesize of the factual information to arrive at valid conclusions
5. To enable students to communicate technical information in the form of oral presentation and technical report in the form of project.

EVALUATION:

- The progress of the project is evaluated based on a minimum of three reviews.
- The review committee may be constituted by the Head of the Department.
- A project report is required at the end of the semester. The project work is evaluated jointly by external and internal examiners constituted by the Head of the Division based on oral presentation and the project report.
- Project work evaluation is based on the Regulations of the Credit system for Post graduate programmes of Anna University

COURSE OUTCOMES:

Upon completion of this project, the students will be able to

CO1 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, organised, coordinated project outcome of the aimed work.

CO2 Design, model and experiment/develop optimal solutions for problems being investigated.

CO3 Analyse and interpret the experimental data from various machining methods and synthesis of the information to provide valid conclusions and submit reports.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	3	3	3	3	3	3.0
CO2	3	3	3	3	3	3	3.0
CO3	3	3	3	3	3	3	3.0
POs Average	3.0	3.0	3.0	3.0	3.0	3.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

CI3051 ADVANCES IN WELDING AND CASTING TECHNOLOGY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To impart knowledge on welding Metallurgy, Design and Special welding processes.
2. To elaborate gating system design and casting metallurgy and to provide knowledge on Special casting processes.
3. To familiarize the students with automation and environmental aspects and standards.

UNIT I WELDING DESIGN 9

Heat Flow in Welding: Welding Thermal Cycle (WTC)- Effect of WTC and Cooling Rate in Welding-Cooling Rate- Peak Temperature and Solidification Rate- - Residual Stress- Residual Stress - Design of Weld Joints: Introduction to Design of Weld Joints- Types of Joints and Welds- Edge Preparation- Design for Static and Fatigue Loading- Fatigue Fracture of Weld Joints-- Fatigue Fracture of Weld Joints.- Understanding Weldability-Reactions in Weldment- Failure Analysis and Prevention Testing of Welding joints -– Case Studies.

UNIT II SPECIAL WELDING PROCESSES 9

Micro joining And Nano joining, Wire Bonding; Fundamentals and Types of Laser Welding Including Hybrid Processes, Laser Properties; Stud Welding And Mechanical Fasteners; Magnetically Impelled Arc Welding; Advanced Gas Tungsten Arc Welding; Flux Cored Arc Welding; Electron Beam Welding; Cold Pressure Welding; Ultrasonic Welding; Explosive Welding; Diffusion Bonding; Friction Stir Welding; Electromagnetic Pulse Welding; High Velocity Projectile Impact Welding-Under water welding-Diffusion bonding.

UNIT III CASTING DESIGN AND SOLIDIFICATION 9

Introduction - - Pattern allowances- Introduction of gating design-Types of gate-Pouring time calculation-Aspiration effects in gating system-Problem solving on gating design-Solidification analysis-Risering methods-Shape factor-Feeding & Chills effect-Problem related to riser design-Design of thin and unequal sections - mechanism of solidification -Rapid solidification processing (RSP) - Melt spinning -Roll quenching - Vibratory solidification -Splat cooling - Thixoforming – Rheocasting - Single crystal growing- Casting defects, inspection, diagnosis and rectification – Case studies

UNIT IV SPECIAL CASTING PROCESSES 9

Evaporative Pattern Casting Process and full mould process – Vaccum sealed moulding - vacuum casting - Magnetic Moulding - Squeeze Casting-types – Mega Casting-Plaster mould casting - Ceramic mould casting.

UNIT V AUTOMATION ENVIRONMENTAL ASPECTS, SPECIFICATION AND STANDARDS 9

Fundamentals of Foundry automation-: Sand Plant, Material Handling, Mould and Core Making-Pollution control, energy and waste management in foundries. Fundamentals of welding automation - Principles of robotic welding- Welding robots, Positioners and Manipulators - Welding sensors and data acquisition Arc sensing-, Weld Seam Tracking-Vision system- Microprocessor based control - Effects of welding fumes on environment. Codes, Specifications and Standards: American Society of Mechanical Engineers (ASME), American Petroleum Institute, American Society for Testing Materials (ASTM).

TOTAL: 45 PERIODS

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

COURSE OUTCOMES:

At the end of the course, students will be able to

CO 1: Use design knowledge to overcome defects in welding
CO 2: Select suitable welding process for the given applications.
CO 3: Use design knowledge to produce quality casting.
CO 4: Select suitable casting process for the given applications.
CO 5: Implement automation principles with environment consciousness techniques in welding and casting plants and learn to follow standards.

CO - PO MAPPING :

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	3	3	3	3	2.7
CO2	3	1	3	3	3	3	2.7
CO3	3	1	3	3	3	3	2.7
CO4	3	1	3	3	3	3	2.7
CO5	3	1	3	3	3	3	2.7
POs Average	3.0	1.0	3.0	3.0	3.0	3.0	

REFERENCES:

1. American Welding Society," Welding Handbook", Volume 110th Edition, 2019.
2. Dieter Radaj, "Design and Analysis of Fatigue Resistant Welded Structures", Woodhead Publishing, United Kingdom, 1990, ISBN: 978-1855730045.
3. John Campbell, "Complete Casting Handbook: Metal Casting Processes, Metallurgy, Techniques and Design", 2nd edition, Butterworth-Heinemann., United Kingdom, 2015, ISBN: 978-1856178099.
4. Mahi Sahoo and Sam Sahu, "Principles of Metal Casting", McGraw-Hill Education, United States, 3rd Edition, 2017, ISBN: 9339218167.
5. Robert B. Tuttle, "Foundry Engineering: The Metallurgy and Design of Castings", Create Space Independent Publishing Platform, Amazon, 2012, ISBN: 9781478157434.
6. Ramesh Singh, "Applied Welding Engineering: Processes, Codes and Standards", First Edition, Elsevier, 2012, ISBN: 978-0-12-391916-8.

MN3001 LASER PROCESSING OF MATERIALS **L T P C**

3 0 0 3

COURSE OBJECTIVES:

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

1. Obtain an overview type of laser and optics
2. Acquire knowledge about all the possible interaction of materials with laser.
3. Get an insight to the joining of materials by laser.
4. Study the process of laser surface modification and forming
5. Get an exposure to laser optics and control for texture, marking, drilling and cutting.

UNIT – I INTRODUCTION TO LASERS AND OPTICS 9

Laser medium (solid state medium: crystals, glass, semiconductor, gaseous medium: CO2, N2, Ar, He-Ne, liquid: die solution, other organic materials). Phenomenon of population inversion. Laser cavity (fiber laser, and other cavities), generation of coherent beam, Q-switching, short pulse generation, power amplification. Laser Beam Characteristics, Wavelength, Coherence, Mode and Beam Diameter, Polarisation, Focusing with a Single Lens, Final Spot Size, Depth of Focus, Optical Components, Lens Doublets, Depolarisers, Collimators, Metal Optics, Diffractive Optical Elements - Holographic Lenses, Laser Scanning Systems, Fibre Delivery Systems.

UNIT – II LASER MATERIAL INTERACTION 9

Heating by Laser, temperature distribution, Thermo liaison and heat flow, impact of absorption on temperature. Melting & solidification: Regimes of laser remelting, interference characteristics Evaporation & Plasma formation – its fundamentals, Hydrodynamics, ionization of vapour, gas breakdown evaporation at moderate irradiance levels, beam heating and evaporation, vapour expansion and recoil. Laser supported combustion waves, plasma enhanced coupling, effects of laser supported detonation waves on beam material interaction- -Laser Safety.

UNIT– III LASER JOINING 9

Laser Welding Parameters: Beam Power, Spot diameter and Traverse Speed;, Effect of Beam Characteristics: Beam Mode, Beam Stability, Beam Polarization, Pulsed Beams, Plasma Formation, Gas Shielding, and Effect of Ambient Pressure, Beam Size and Focal Point Location, Joint Configuration; Welding Efficiency; Mechanism of Laser Welding: Conduction Mode Welding, Keyhole Welding; Material Considerations; ferrous, Nonferrous alloys, Ceramics, Polymers, Dissimilar Materials; Weldment Discontinuities: Porosity, Humping, Spiking; Advantages and Disadvantages of Laser Welding; Special Techniques; Heat Treatment; Specific Applications.

UNIT – IV LASER SURFACE MODIFICATIONS AND FORMING 9

Laser Surface Heat Treatment: Process parameters; Temperature Field; Microstructural Changes in Steels; Nonferrous Alloys; Hardness Variation; Residual Stresses; Advantages and Disadvantages of Laser Surface-Treatment; Laser Surface Melting; Laser Direct Metal Deposition: Processing Parameters, Methods for Applying the Coating Material, Dilution; Advantages and Disadvantages of Laser Cladding; Laser Physical Vapor Deposition (LPVD); Laser Shock Peening: Analysis, Advantages and Disadvantages of Laser Shock Peening. Laser Forming: Principle of Laser Forming, Process Parameters; Laser Forming Mechanisms: Temperature Gradient, Mechanism, Buckling Mechanism, Upsetting Mechanism; Process Analysis; Advantages and Disadvantages; Applications

UNIT – V LASER MACHINING 9

Forms of Laser Cutting: Fusion Cutting, Sublimation Cutting, Photochemical Ablation- Laser instrumentation for cutting and drilling, cut quality and process characteristics methods of cutting material consideration, practical performance, process variations, Dot matrix marking, Engraving, Image micromachining- Micromachining

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Explain the laser source and its parameters.

CO2 Describe the material- laser interaction.

CO3 Summarise laser joining of materials.

CO4 List the various surface modification and forming using lasers

CO5 Interpret laser process parameters for machining.

REFERENCES:

1. Elijah kannatey-Asibu, Jr., “Principles of Laser Materials processing “, Wiley, 2nd Edition, 2023.
2. William M. Steen, “Laser Material Processing”, Springer, 3rd Edition, 2013
3. Jacques Perriere, Eric Millon, Eric Fogarassy, “Recent Advances in Laser Processing of Materials”, Elsevier Science, 2006
4. Jonathan R. Lawrence,” Advances in Laser Materials Processing: Technology, Research and Application”, Elsevier Science,2nd Edition 2017
5. KamleshwarUpadhya, “Plasma and Laser Processing of Material”, TMS, 1991
6. Peter Schaaf, “Laser Processing of Materials: Fundamentals, Applications and Developments”, Springer Science & Business Media,2010

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	2	1	1	1	2	1.7
CO2	2	2	1	1	1	2	1.5
CO3	1	1	2	2	2	2	1.7
CO4	1	1	2	2	2	2	1.7
CO5	2	2	2	2	2	2	2.0
POs Average	1.8	1.6	1.6	1.6	1.6	2.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3002	MANUFACTURING SYSTEMS AND MODELS	L	T	P	C
		3	0	0	3

COURSEOBJECTIVES:

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

1. To understand various measure the performance of manufacturing system
2. To Know how to apply DTMC model to a Manufacturing system
3. To Know how to apply CTMC model to a Manufacturing system
4. To understand Queuing networks and to model queuing network for a Manufacturing system
5. To understand and apply the Petri net model to a Manufacturing system

UNIT I MANUFACTURING SYSTEMS- PERFORMANCE MEASURES 9

Manufacturing systems- Types, Concepts. Performance measures- types. Manufacturing Models Types. Factory Models- Single Workstation Factory Models-Developing Rate Balance Equations- Assembly Lines- Transfer Lines

UNIT II DISCRETE TIME MARKOV CHAINS 9

Introduction to Markov Chains, DTMC, Properties of DTMC, Sojourn Times in DTMC Models, Applications of DTMC Models in Manufacturing Systems

UNIT III CONTINUOUS TIME MARKOV CHAINS 9

Introduction to CTMC, Properties of CTMC, Sojourn Times in CTMC Models, Applications of CTMC Models in Manufacturing Systems

UNIT IV QUEUING MODELS 9

Birth and death process, performance measures in queuing models, open queuing networks and closed queuing networks- applications in manufacturing systems

UNIT V PETRINET MODELS 9

Introduction to Petri-net models-Representational powers of Petri-Nets- Reachability graphs, Markings, Applications of Petri-Nets models in manufacturing systems- Timed and Colored Petri-Nets

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to

CO1 Identify and measure the performance of manufacturing system
CO2 Apply the DTMC model to a Manufacturing systems
CO3 Apply the CTMC model to a Manufacturing system
CO4 Apply the Queuing network model to a Manufacturing system
CO5 Apply the Petrinet model to a Manufacturing system

REFERENCES:

1 Viswanadham, N., &Narahari, Y., Performance modeling of automated manufacturing systems, Prentice Hall, 1992

2 Ronald G. Askin Charles R. Stand ridge, Modelling and analysis of manufacturing systems, John Wiley and son's .Inc, 1993.
3 Guy L. Curry., Richard M. Feldman "Manufacturing Systems Modeling and Analysis", Springer, 2011.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	1	1	1	1	1.3
CO2	3	2	1	2	2	1	1.8
CO3	3	2	1	2	2	1	1.8
CO4	3	2	1	2	1	1	1.7
CO5	3	2	1	2	1	1	1.7
POs Average	3.0	1.8	1.0	1.8	1.4	1.0	

1 – Slight, 2 – Moderate, 3 - Substantial

MN3003	BIO-INSPIRED MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. To examine and mimic the natural hierarchical structure.
2. To understand nature specific surface characteristics and replicate them.
3. To introduce to toughness mechanism in nature and apply them for composite fabrication
4. To understand the sensors/actuators in nature and bio inspired MEMS
5. To educate the use information flow and functionality of nature for manufacturing systems

UNIT – I MANUFACTURING BIO INSPIRED HIERARCHICAL STRUCTURE 9

Nature hierarchical structure- levels (dense and porous) – improved properties- bone –bamboo-cellular structure-honeycomb- negative Poisson ratio structure- sandwich structure- hierarchical order – strength ratio- Manufacturing: Layered manufacturing- Mould and gel casting- Particulate Leaching-Foaming-Compression moulding and hot pressing-Low-pressure injection moulding and extrusion- ultrasonic cavitation –Applications.

UNIT – II MANUFACTURING BIO INSPIRED SURFACES 9

Nature dry adhesion (Gecko effect -Attaching/detaching mechanisms)- Wet adhesion (tree frogs)- Super-hydrophobicity (Lotus effect) –super hydrophilic (plant) - Antibiofouling (shark skin)- Optical tuning (Iridescent peacock feathers) – hard and tough (Teeth)- hydrodynamic drag (shark skin, boxfish)-Manufacturing: soft lithography-hot-embossing- Plasma etching- Electron-beam lithography- Porous alumina membrane molding- sputtering- Electrodeposition-Thermal Evaporation-Electrostatic spray coating-Chemical surface modification-laser texturing- atomic layer deposition-photocurable resin-UV exposure Applications.

UNIT– III MANUFACTURING BIO INSPIRED COMPOSITES 9

Nature – Seashells- abalones- toughening mechanisms – interlocking of nano-asperities – weak organic interfaces, inter-lamellar mineral bridges, plastic deformation of individual tile –multiple cracking large-scale crack bridging- Lobster - armadillo's dermal shells- Sandwich structure of turtle carapace- Diatoms-plant stem –self healing composites- freeze casting method-clay/polyimide composites fabricated from centrifugal - additive manufacturing- Applications

UNIT – IV MANUFACTURING BIO INSPIRED SENSORS AND ACTUATORS 9

Thermal sensor (beetle, snakes) – Echolocation (crickets, bats) – Vision (Avian eyes, honeybees' eye) – microelectromechanical system (MEMS) sensor based on piezoresistive, capacitive, triboelectric, and piezoelectric – display – muscles – artificial muscles- electrothermal-capacitive- piezoelectric based MEMS actuators.

UNIT – V BIOINSPIRED MANUFACTURING SYSTEMS 9

Multi-Agent Systems (MAS)-Holonic Manufacturing Systems (HMS) –Bionic Manufacturing Systems (BMS)-swarm intelligence-positive and negative feedback- Self-Organization-Self-configuration, Self-optimization, Self-healing. Ant Colony Optimization (ACO), Artificial Bee Colony (ABC)Algorithm and Particle Swarm Optimization (PSO). MAS- Distributed nature-Division of labor- Emergence from collective simple behavior. Biologicalisation in Manufacturing-Alternative or fail-safe mechanisms: Modularity Decoupling -–Case Studies–Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Summarize the natural hierarchical structure and methods of manufacturing
CO2 Describe the nature specific surface characteristics and method of manufacturing features.
CO3 List the various toughness mechanisms in nature and composite fabrication involving those features.
CO4 Compare the various the sensors/actuators in nature and manufacture them based on MEMS
CO5 Explain basic understanding on information flow and functionality of nature and application to manufacturing systems

REFERENCES:

1. Yoseph Bar-Cohen, “Biomimetics: Biologically Inspired Technologies”, CRC Press, 2016.
2. Bhushan Bharat, “Biomimetics: lessons from nature–an overview”, Phil. Trans. R. Soc. A., 2009.
3. Po-Yu Chen, Joanna McKittrick, Marc André Meyers, "Biological materials: Functional adaptations and bioinspired designs", Progress in Materials Science, Volume 57, Issue 8, 2012, Pages 1492-1704.
4. Gerald Byrne, Dimitri Dimitrov, Laszlo Monostori, Roberto Teti, Fred van Houten, Rafi Wertheim, "Biologicalisation: Biological transformation in manufacturing", CIRP Journal of Manufacturing Science and Technology, Volume 21, 2018, Pages 1-32.
5. Ilami, M., Bagheri, H., Ahmed, R., Skowronek, E. O., Marvi, H., “Materials, Actuators, and Sensors for Soft Bio Inspired Robots”. Adv. Mater. 2021.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	2	1	1	1	1.3
CO2	2	1	2	1	1	1	1.3
CO3	2	1	2	1	2	1	1.5
CO4	2	1	2	1	2	2	1.7
CO5	2	1	2	1	1	2	1.5
POs Average	2.0	1.0	2.0	1.0	1.4	1.4	
1 – Slight, 2 – Moderate, 3 - Substantial							

CI3053	**MICRO AND NANO MANUFACTURING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

OBJECTIVES:

1. To introduce Meso, Micro and Nano manufacturing and their respective applications.
2. To familiarize the students with diamond, turn machining, advanced micro machining and nano finishing methods.
3. To familiarize the students with synthesis of nanomaterials and types of characterization techniques to be used.

UNIT I INTRODUCTION 9

Introduction to Meso, Micro and Nano manufacturing, Miniaturization and applications,classification- subtractive, additive, mass containing processes, Theory of micromachining, micro turning, micro drilling, micro milling- Micro stereo lithography - micro forming, micro moulding, micro casting- micro joining, Applications of Micro and Nano products in IT and telecommunications, Automotive, Medicine.

UNIT II DIAMOND TURNING 9

Diamond turn machining-need, classification, components, material removal mechanisms,Tooling for diamond turning, Process parameters and optimization - Molecular Dynamicsimulation to study nanoscale cutting-tool path strategies in surface generations- symmetric,asymmetric and freeform, applications of DTM products.

UNIT III ADVANCED MACHINING / FINISHING PROCESSES 9

Introduction to mechanical and beam energy based micro machining processes- Ultrasonic micro machining, Focused Ion Beam machining, Laser Beam micro machining, Pulsed water drop 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. Nano wires.

UNIT V CHARACTERISATION TECHNIQUES 9

Metrology for micro machined components -Optical Microscopy, White Light Interferometry, Molecular Measuring Machine, Micro CMM- Atomic Force Microscopy.
Scanning Probe Microscopy (SPM) – Scanning Electron Microscope, Transmission Electron Microscope, Scanning Thermal Microscopy, Tribological characteristics -Micro abrasion wear - 3D surface roughness measurement- Nano indentation- Ellipsometric Analysis.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to

CO 1:Recognize the importance of Meso, Micro and Nano manufacturing and their respective applications.
CO 2: Elaborate on Diamond turn machining process
CO 3: Describe the advanced micro machining and nano finishing methods.
CO 4: Acquire knowledge on synthesis of nanomaterials
CO 5: Identify the type of characterization techniques to be used.

Attested

CO - PO MAPPING :

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	3	3	2	3	3
CO3	3	3	3	2	3	3
CO4	3	3	3	2	2	1
CO5	3	3	3	2	2	2

REFERENCES:

1. Jain, V.K, "Micro manufacturing Processes", by CRC Press, ISBN: 9781439852903, 2013.
2. Bhushan, B., "Handbook of Nanotechnology", Springer, Germany, ISBN-13: 978-3662543559, 2017.
3. Jain, V.K "Introduction to Micromachining", Narosa publishing house, ISBN: 978-81-7319-915-8, 2014.
4. Balasubraminan, R., RamaGopal, V., SarepakaSathyanSubbiah "Diamond Turn Machining: Theory and Practice" by CRC Press, ISBN-13:978-1-4987-8758-1,2018.
5. DehongHuo, Kai Cheng "Micro-Cutting: Fundamentals and Applications (Microsystem and Nanotechnology)" by Wiley, ISBN-13: 978-0470972878, 2013.
6. Yang Leng "Materials Characterization: Introduction to Microscopic and Spectroscopic Methods" by Wiley-VCH, ISBN-13: 978-3527334636, 2013
7. Bandyopadhyay, A.K., "Nano Materials", New Age International Publishers, New Delhi, SBN 8122422578, 2008.
8. Grundy, P.J. and Jones, G.A."Electron Microscopy in the Study of Materials", Edward Arnold Limited, 1976.

MN3004	SMART MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. To introduce smart and intelligent materials and its principles.
2. To impart knowledge on materials exhibiting piezoelectricity and their applications.
3. To familiarise the synthesis and application of Electro/ Magneto rheological fluids and their applications.
4. To summarise various shape memory alloys and polymers, their production methods and applications.
5. To introduce smart materials that reconfigure structure based on stimulus and other emerging materials.

UNIT – I INTRODUCTION TO SMART AND INTELLIGENT MATERIALS 9

Intelligent / Smart materials –classification- Culshaw information- hybrid smart materials - an algorithm-for synthesising smart materials – active, passive reactive actuator based smart structures - Functional materials – Polyfunctional materials – Structural materials -Electrical materials- electro-restrictive and magneto-restrictive materials- Principles of Piezoelectricity, Perovskyte- Bingham body model –electro-rheological fluids(ERF)- Shape Memory Effect-– thermoelastic martensitic transformations- Biomimetics.

UNIT – II PIEZOELECTRIC MATERIALS 9

Piezo ceramic Materials, Single Crystals vs Polycrystalline Systems, Piezoelectric Polymers- - Overview of production method-poling- Modelling Piezoelectric Actuators, Amplified Piezo Actuation – Internal and External Amplifications-Piezoelectric Strain Sensors, In-plane and Out-of Plane Sensing, Shear Sensing, Accelerometers, Effect of Electrode Pattern-Self-Sensing Piezoelectric Transducers, Energy Harvesting Materials

UNIT– III MAGNETO/ELECTRO-RHEOLOGICAL FLUIDS 9

Suspensions- Overview of production method- electro-rheological fluids - principal characteristics of electro-rheological fluids (ERF) –mechanism for the dispersed phase – electrorheological fluid domain – fluid actuators- design parameter – application of Electro-rheological- fluids – Basics, Principles and instrumentation and application of Magnetorheological fluids (MRF)- applications of ERF/MRF

UNIT – IV SHAPE MEMORY MATERIALS 9

Shape Memory Alloys, Nickel – Titanium alloy (Nitinol) —– classification of SMA alloys-mechanism of magnetic SMA –Shape Memory Polymers- mechanism of shape memory- types and applications - Overview of production method- Primary moulding – secondary moulding-Shape Memory Actuators, Active Vibration Control, Active Shape Control, Passive Vibration Control, Hybrid Vibration Control

UNIT – V STIMULI RESPONSIVE MATERIALS AND EMERGING MATERIALS 9

Halochromic materials, pH-sensitive polymers, Chromogenic-systems, photochromic-Thermochromic- electrochromic- high entropy alloys- bulk metallic glass- metamaterials-topological materials- self healing materials- Autophagias Materials- Overview of production method – Application of smart material incorporated structures – health monitoring- vibration mitigation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Discuss on the mechanism and structure of various smart materials
CO2 Select piezoelectric materials, elaborate applications of them.
CO3 Explain the working of ERF/MRF applications.
CO4 Explain the various kinds of shape memory materials, their production and applications.
CO5 List the property and principles of various stimuli response materials and emerging materials

REFERENCES:

1. M Shahinpoor and Hans-Jorg Schneider, "Intelligent Materials", Royal Society of Chemistry Press 2009.
2. Inderjit Chopra, Jayant Sirohm, "Smart structures theory", Cambridge University Press, First edition, 2014.
3. K. Otsuka and C. M. Wayman, "Shape Memory Materials", Cambridge Press 2002..
4. Culshaw, B., "Smart Structures and Materials," Artech House, Inc., First Edition, 1996.
5. Mark Madou, "Fundamentals of Microfabrication ", CRC Press, Third Edition, 2018.
6. Donald J.Leo,."EngineeringAnalysis of Smart Materials Systems", John Wiley publications, 2011.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	1	1	1	1	1.2
CO2	2	1	1	2	2	2	1.7
CO3	2	1	1	2	2	2	1.7
CO4	2	1	1	2	2	2	1.7
CO5	2	1	2	2	-	2	1.8
POs Average	2.0	1.0	1.2	1.8	1.8	1.8	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3005 MATERIAL TESTING AND CHARACTERIZATION L T P C

3 0 0 3

COURSE OBJECTIVES:

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

1. To provide understanding of techniques of microstructure and crystal structure evaluation
2. To introduce electron microscopic tools for analysis of material topography and compare to atomic force microscopy
3. To understand the typical techniques of evaluation of chemical composition and thermal analysis of materials.
4. To familiarise advanced static mechanical testing methods.
5. To summarise the various dynamic mechanical testing methods.

UNIT – I MICRO AND CRYSTAL STRUCTURE ANALYSIS 9

Principles of Optical Microscopy – Specimen Preparation – Polishing and Etching of common metal alloys – Polarization – Phase contrast – Differential interference Contrast- Microscopy-Quantitative Metallography – X- ray Diffraction – Bragg’s law –Diffractometer – analysis of diffraction patterns – Interplanar spacing – Determination of grain size, crystal structure, phase, indexing of peaks - Introduction to estimation of residual stress- orientation- texture.

UNIT – II ELECTRON MICROSCOPY 9

Interaction of Electron Beam with Materials – Transmission Electron Microscopy – Specimen Preparation – Imaging Techniques – BF & DF – Selected Area Electron Diffraction– Electron Probe Microanalysis – Scanning Electron Microscopy – Construction & working of SEM– imaging modes–-electron backscattered diffraction- preparation for biological samples-Applications-Atomic Force Microscopy- Construction & working of AFM Contact and Non-Contact modes Applications.

UNIT– III CHEMICAL AND THERMAL ANALYSIS 9

Basic Principles, Practice and Applications of Energy dispersive Spectroscopy and Wave Dispersive Spectroscopy, X-ray Photoelectron spectroscopy- Auger Spectroscopy, Inductively Coupled Plasma Optical Emission spectroscopy (ICP-OES)-Secondary Ion Mass Spectroscopy, Fourier Transform Infra-Red Spectroscopy (FTIR)- Raman Spectroscopy- Differential Thermal Analysis, Differential Scanning Calorimetry (DSC) –Thermogravimetric metric Analysis (TGA)-Dynamic Mechanical Analysis (DMA).

UNIT – IV MECHANICAL TESTING – STATIC TESTS 9

Micro Hardness –Nanoindentation test- Scratch test - Tensile Test – Stress – Strain plot – for plastic deformation under different strain rate and temperature – Instrumented Charpy Test – Fracture Toughness Test- Typical testing of laminate composites.

UNIT – V MECHANICAL TESTING – DYNAMIC TESTS 9

Fatigue – Low & High Cycle Fatigue tests – SN curve – Crack Growth studies – Creep Tests – Larson-Miller Parameter– Indentation creep test – Acoustic emission Tests- modal analysis – Applications for Life Estimation-Ballistic impact- Wear Test.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

- **CO1** Compare the contrast enhancement by various metallography and derive information from X-ray diffraction for defining material.
- **CO2** Describe the principle of image formation in electron microscopy and atomic force microscopy.
- **CO3** Select the technique(s) for determining chemical composition and explain properties that can be reported from thermal analysis.
- **CO4** Compare typical test results and procedures for static testing of materials.
- **CO5** Identify typical test results and procedures for dynamic testing of materials.

REFERENCES:

1. Cullity B.D, Stock S. R, Stock S, “Elements of X ray Diffraction”, Prentice Hall, 3rd Edition, 2015.
2. Angelo P. C, “Materials Characterisation”, Cengage Publication, 1st Edition,2016.
3. Dieter G.E., “Mechanical Metallurgy”, McGraw Hill, (3rd Edition), 2017. ISBN: 0070168938,
4. Suryanarayana A. V. K, “Testing of metallic materials”, BS publications, 2nd Edition ,2018.
5. Yang Leng, “Materials Characterization: Introduction to Microscopic andSpectroscopic Methods”, Wiley, 2nd Edition, 2013.
6. “ASM Handbook – Materials Characterization”, Vol-10, 2019.
7. C. Suryanarayana, “Experimental Techniques in materials and Mechanics”, CRC Press, 2011

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	1	2	2	1	1.7
CO2	3	1	1	2	1	1	1.5
CO3	3	1	1	2	1	1	1.5
CO4	3	1	1	2	2	-	1.8
CO5	3	1	1	2	2	-	1.8
POs Average	3.0	1.0	1.0	2.0	1.6	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

MN3006 **MANUFACTURING METROLOGY**

L	T	P	C
3	0	0	3

OBJECTIVES:

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

1. To teach the students about the concepts of metrology.
2. To train the students in the field of surface roughness measurement
3. To acquire knowledge on form measurements and interferometry.
4. To introduce some fundamental principles of CAI, Laser metrology
5. To understand Image processing on Machine vision.

UNIT I CONCEPTS OF METROLOGY 9

Introduction - Terminologies - Standards of measurement - Interchangeability - Selective assembly - Accuracy and Precision – Calibration of instruments – Errors in measurements – Limits – Fits - Tolerances – Process capabilities - Laboratory accreditation, Basics of dimensional metrology and Form metrology – Form, Fits, functions, Clean room - Maintenance and handling of metrology equipment's - Standard practices of inspection rooms – Linear and Angular measurements – Comparators.

UNIT II SURFACE ROUGHNESS 9

Fundamentals of GD & T - Conventional vs Geometric tolerance, Interpretation of GD&T Symbols in engineering drawings, Datums, Inspection of geometric parameters, Material conditions - concept of bonus tolerance. Surface Roughness Measurement Methods - parameters, Contact and Non-Contact type, 3D Surface Roughness Measurement - Nano Level Measurement, Atomic Force Microscopy (AFM).

UNIT III INTERFEROMETRY AND FORM MEASUREMENTS 9

Introduction - Principles of Interferometry - Optical flats in assessing surface contours - Interferometers – Measurement and Calibration - Laser Interferometry - Engineering applications of interferometry - Form measurements - flatness, straightness, roundness, cylindricity.

UNIT IV COMPUTER AIDED INSPECTION AND LASER METROLOGY 9

Introduction – Computer Aided Inspection Techniques - Tool Makers Microscope – Coordinate Measuring Machines - Advantages, limitations– Applications-Straightness-Alignment: Ball bar tests – Advanced Laser gauging techniques – Lasers in precision Measurements – Laser Scanners for Reverse Engineering - In-process inspection -Industrial case studies. DIC (digital image correlation), Perceived quality.

UNIT V MACHINE VISION AND IMAGE PROCESSING 9

Overview of Machine Vision systems-Elements-Image Acquisition, Image enhancement and Analysis-Vision based GD&T- Image processing Software- 3D reconstruction techniques for measurements and their integration with vision systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to

CO1 Explain the fundamental concepts of measurement, standards, calibration, maintenance of laboratory facilities and handling of metrological equipments

CO2 Explain roughness and its applications in manufacturing research, learn the important concepts, principles and applications related to interferometry.

CO3 Discuss the use of interferometry related sophisticated measurement and inspection facilities.

CO4 Execute the concepts of Computer aided inspection technologies for industrial Situations, design and develop new inspection techniques.

CO5 Describe the importance of image processing techniques and the possibilities of developing new heuristics for image processing related to metrology.

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, 2009.
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, 2002.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	2	3	3	3	2.5
CO2	3	1	2	3	3	3	2.5
CO3	3	1	2	3	3	3	2.5
CO4	3	1	2	3	3	3	2.5
CO5	3	1	2	3	3	3	2.5
POs Average	3.0	1.0	2.0	3.0	3.0	3.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3007	GREEN MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. To expose the students to the basics of environmental sustainability and impact assessment objectives
2. To incorporate knowledge about the environmental based improvements towards lean manufacturing systems
3. To analyze various machineries with intent to conserve energy
4. 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.
5. To impart the knowledge about the need, procedure and benefits of Green-Co-rating

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

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Explain the Concepts of environmental sustainability and environmental impact assessment objectives.

CO2 Apply suitable schemes towards design of green manufacturing requirements.

CO3 Analyze manufacturing processes towards conservation of energy.

CO4 Analyze manufacturing processes towards minimization or prevention of hazardous and solid wastes.

CO5 Build the knowledge of green co-rating and its benefits are well known to the students.

REFERENCES:

1. Dornfield David, “Green Manufacturing”, Springer,2013
2. Davim J Paulo, “Green Manufacturing Processes and Systems”, Springer,2013
3. Cairncross and Francis, “Costing the earth”, Harvard Business School Press, 2009
4. World Commission on Environment and Development (WCED) “Our Common Future”, Oxford University Press, 1987.
5. “Green Co Case Study Booklet”, CII–Sohrabji Godrej Green Business Centre,2015.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	1	2	1	1	1.3
CO2	2	1	1	2	1	1	1.3
CO3	2	1	1	2	1	1	1.3
CO4	2	1	1	2	1	1	1.3
CO5	2	1	2	2	1	2	1.7
POs Average	2.0	1.0	1.2	2.0	1.0	1.2	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3008 **POWDER PROCESSING**

L	T	P	C
3	0	0	3

COURSE OBJECTIVES

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

1 To understand the fundamental of characterization of powders and particulates.
2 To understand methods for the production of powder
3 To introduce to particle interaction, mixing and sintering
4 To understand the powder transport and rheology of powder solution
5 To introduce the methods of production of nano sized powders

UNIT I POWDER CHARACTERIZATION 9

Powder size – distribution- shape- surface charges – BET surface area analysis– dynamic light scattering – flowability- apparent and tap density- Cohesiveness- internal powder porosity- powder characteristic suitable for additive manufacturing- Powder satellite content

UNIT II POWDER PRODUCTION 9

Water- Gas- plasma- centrifugal -atomization- hydride-dehydride- rapid spinning cup process (RSC), vacuum (soluble gas) atomization (VA), rapidsolidification rate (RSR) process for rotating disk atomization, (free-fall) gas (Ar)atomization (GA), and rotating electrode process (REP)- induction melting gas atomization (EIGA)- comparison of powder characteristics by various methods- selective laser beam melting of polymers (LBM)

UNIT III PARTICLE INTERACTIONS 9

Solid-Solid Mixing - Interparticle Forces- Mixing – mechanism of mixing, types of mixers – batch and continuous mixers – pan mixer, shaft mixer, U mixer, muller mixer and other mixers, liquid mixers – mechanism, blungers, agitators - particle- gas interaction- Nucleation, condensation, evaporation, and hygroscopicity-– Reprocessing of powders- Theory of Sintering, Sintering of Single- Mixed Phase Powder, Liquid Phase Sintering.

UNIT IV POWDER TRANSPORT AND RHEOLOGY OF SOLUTION 9

Conveying – solid conveying-types of conveyors, Vibrational Microfeeding- criteria for selecting a conveyor; liquid conveying- condition for liquid conveying- Brownian motion- Characteristics on Rheological Properties of suspension/ solution- Pneumatic Conveying of particulate Solids- - Gas Fluidization different types of pumps. Storage methods for different ceramic powders. Problems in bin storage.Colloids – Types – Surface forces – Stabilisation – Colloidal suspension – Electrostatic, steric and electrosteric – structure and Rheology of colloidal suspensions

UNIT V NANOSIZED POWDER PRODUCTION 9

Processes for producing ultrafine powders Mechanical grinding; Wet Chemical Synthesis of Nano-materials- sol gel process; Gas Phase synthesis of Nano-materials Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation (CVC)- comparison of powder characteristics by various methods – Safety measures

TOTAL : 45 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to

CO1 Identify techniques of characterization of powders and particulates.
CO2 List and brief on the methods for the production of powder
CO3 relate the powder behaviour due particle interaction and describe sintering.
CO4 Explain the powder transport and rheology of powder solution
CO5 Discuss on the methods of production of nano sized powders

REFERENCES

1. P.C.Angelo and R.Subramanian.,“ Powder Metallurgy: Science, Technology and Application” Prentice Hall, 2008
2. Anish Upadhya and G S Upadhaya, “ Powder Metallurgy: Science, Technology and Materials, Universities Press, 2011
3. Advances in Powder Metallurgy: Properties, Processing and Applications, Isaac Chang, Yuyuan Zhao, Woodhead Publishing Series in Metals and Surface Engineering, Elsevier, 2013.
4. ASM Hand Book, vol. 7: Powder Metallurgy, ASM International
5. J. S. Hirschhorn, Introduction to Powder Metallurgy, American Powder Metallurgy Institute, Princeton, NJ, 1976
6. G. S Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, 2002. 2nd Edition

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	2	1	1	2	1	1.3
CO2	2	2	3	1	1	2	1.8
CO3	2	2	1	2	2	1	1.7
CO4	2	2	1	2	2	1	1.7
CO5	1	2	3	2	2	1	1.8
POs Average	1.6	2.0	1.8	1.6	1.8	1.2	
1 – Slight, 2 – Moderate, 3 - Substantial							

IL3251 SUPPLY CHAIN SYSTEMS AND MANAGEMENT L T P C

3 0 0 3

COURSE OBJECTIVES:

1. To describe the role and drivers of and supply chain management in achieving competitiveness.
2. To explain about Supply Chain Network Design.
3. To illustrate about the issues related to inventory in Supply Chain.
4. To appraise about transportation and sourcing in Supply Chain.
5. To application of Information Technology and Emerging Concepts in Supply Chain.

UNIT I INTRODUCTION TO SUPPLY CHAIN MANAGEMENT 9

Definition and Objective of Supply Chain, The importance of Supply Chain Decisions, Decision Phases in a Supply Chain, Process View of Supply Chains. Competitive and Supply Chain Strategies, Achieving Strategic fit, Expanding Strategic Scope. Drivers of Supply Chain Performance, Frame work for Structuring Drivers, Facilities, Inventory, Transportation, Information, Sourcing, Pricing, Infrastructure, International Logistics

UNIT II DISTRIBUTION NETWORK DESIGN IN SUPPLY CHAIN 9

The Role of Distribution in the Supply Chains, Factors influencing Distribution Network design, Design Options for a Distribution Network, Online sales and the Distribution network, Distribution Networks in practice. Factors influencing network design decisions, Framework for Network design decisions, The impact of uncertainty on network design, The impact of Globalization on Supply Chain networks, Risk Management in Global Supply Chains, Discounted cash flow analysis, Evaluating Network Design Decisions

UNIT III INVENTORY IN SUPPLY CHAIN 9

The Role of Cycle inventory in a Supply Chain, Economies of Scale to Exploit Fixed costs, Managing Multi-echelon Cycle Inventory. The Role of Safety Inventory in a Supply Chain, Determining appropriate level of Safety inventory, Impact of supply Uncertainty on Safety inventory, Impact of aggregation on safety inventory, impact of replenishment policies on safety inventory, Managing Safety Inventory in a Multi-echelon Supply Chain, The Role of IT in inventory management.

UNIT IV TRANSPORTATION AND SOURCING IN SUPPLY CHAIN 9

The role of transportation in a Supply chain, Modes of transportation and their performance characteristics, Transportation infrastructure and policies, Design options for a transportation network, Trade-offs in transportation design, Tailored transportation, The role of IT in transportation, Problems. Sourcing Decisions In A Supply Chain: The role of sourcing in a supply chain, in-house or outsource, Third-and Fourth-party logistics providers, Total cost of Ownership, Supplier selection, Auctions and Negotiations, Sharing Risk and Reward in the supply chain.

UNIT V INFORMATION TECHNOLOGY IN SUPPLY CHAIN 9

The role of IT in a supply chain, The supply chain IT framework, The supply chain macro processes, Lack of Supply Chain co-ordination and the Bullwhip effect, managerial levers to achieve coordination, continuous replenishment and vendor-managed inventories, collaborative planning, forecasting and replenishment (CPFR).

TOTAL:45 PERIODS

COURSE OUTCOMES:

The students will be able to

Attested

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

CO1. Understand supply chain concepts, systemic and strategic role of SCM in global competitive environment.
CO2. Evaluate alternative supply and distribution network structures using optimization models.
CO3. Develop optimal inventory policies in the supply chain context.
CO4. Develop optimal sourcing and Transportation decisions in the supply chain.
CO5. Select appropriate information technology frameworks for managing supply chain processes.

REFERENCES:

1. Sunil Chopra, Peter Meindl and D.V. Kalra, "Supply Chain Management: Strategy, Planning, and Operation", Pearson Education, 2016.
2. Sarika Kulkarni & Ashok Sharma, Supply Chain Management – Creating Linkages for Faster Business Turnaround, 1st Edition, TATA Mc Graw Hill, 2004.
3. David Simchi Levi, Philip Kaminsky, Edith Simchi Levi & Ravi Shankar, Designing & Managing the Supply Chain – Concepts Strategies and Case Studies, McGraw-Hill higher education, 3rd Edition, 2008.
4. Jeremy F Shapiro, Modelling the Supply Chain, 2nd Edition, Cengage Learning,2009.

CO's-PO's & PSO's MAPPING

CO's	PO's			PSO's		
	1	2	3	1	2	3
1	1	2	1			
2	3	3	1	1	1	1
3	3	3	1	1	1	1
4	3	3	1	1	1	1
5	3	3	1	1	3	1
Avg.	**2.6**	**3**	**1**	**1**	**1.5**	**1**

QE3251 **LEAN SIX SIGMA** **L T P C**

3 0 0 3

COURSE OBJECTIVES

1. To understand Lean production principles, eliminate waste, and improve efficiency through case studies.
2. To learn steps for Value Stream Mapping, apply Lean metrics, and implement improvements in value streams.
3. To explore Six Sigma's relationship with Lean Manufacturing, cultural changes, quality assessment, and cost implications.
4. To gain knowledge of various Six Sigma tools and techniques for problem-solving and project management.
5. To evaluate Six Sigma quality economics, focus on continuous improvement using Lean principles, Kaizen, and 5S methodologies.

UNIT I LEAN MANUFACTURING 9

Evolution of Mass production, Traditional versus Mass production, Evolution of Toyota (Lean) Production System, Business Dynamics of Lean production, Principles of Lean production – Value, Value stream, Flow, Pull, Perfection- 3Ms – Muda, Mura, Muri, 7 Wastes in Manufacturing, Lean Tools to eliminate Muda - 5S, Standardised work, TPM, SMED, Jidoka – Poka Yoke, JIT, Heijunka, Kanban, One piece production, Case studies.

UNIT II VALUE STREAM MAPPING 9

Need for Value Stream mapping; Steps involved in Value stream mapping – Choose value stream – PQ and PR analysis, Current State map, Lean Metrics, Future State Map, Kaizen plans; Lean implementation - Cultural change, Hoshin planning; Lean in the Supply chain.

UNIT III SIX SIGMA 9

Six sigma - lean manufacturing and six sigma- six sigma and process tolerance – Six sigma and cultural changes – six sigma capability – six sigma need assessments - implications of quality levels, Cost of Poor Quality (COPQ)

UNIT IV SIX SIGMA SCOPE OF TOOLS AND TECHNIQUES 9

Tools for definition – IPO diagram, SIPOC diagram, Flow diagram, CTQ Tree, Project Charter – Tools for measurement – Check sheets, Histograms, Run Charts, Scatter Diagrams, Cause and effect diagram, Pareto charts, Control charts, Flow process charts, Process Capability Measurement, Tools for analysis – Process Mapping, Regression analysis, RU/CS analysis, SWOT, PESTLE, Five Whys, interrelationship diagram, overall equipment effectiveness, TRIZ innovative problem solving – Tools for improvement – Affinity diagram, Normal group technique, SMED, 5S, mistake proofing, Value stream Mapping, forced field analysis – Tools for control – Gantt chart, Activity network diagram, Radar chart, PDCA cycle, Milestone tracker diagram, Earned value management.

UNIT V EVALUATION AND CONTINUOUS IMPROVEMENT METHODS 9

Evaluation strategy – the economics of six sigma quality, Return on six Sigma (ROSS), ROI, poor project estimates – continuous improvement – lean manufacturing – value, customer focus, Perfection, focus on waste, overproduction – waiting, inventory in process (IIP), processing waste, transportation, motion, making defective products, underutilizing people – Kaizen – 5S

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1. Demonstrate understanding of Lean production principles, waste identification, and efficiency improvement.

CO2. Apply Value Stream Mapping steps and Lean metrics to enhance organizational performance.

CO3. Analyze the relationship between Six Sigma and Lean Manufacturing, evaluate cultural changes, quality levels, and cost implications.

CO4. Acquire knowledge of Six Sigma tools and techniques for effective problem-solving and project management.

CO5. Evaluate Six Sigma quality economics and demonstrate commitment to continuous improvement through Lean principles, Kaizen, 5S methodologies, and customer focus.

REFERENCES:

1. Michael L.George, David Rownalds, Bill Kastle, What is Lean Six Sigma, McGraw – Hill 2003
2. Thomas Pyzdek, The Six Sigma Handbook, McGraw-Hill,2000
3. Fred Soleimannejed , Six Sigma, Basic Steps and Implementation, AuthorHouse, 2004
4. Forrest W. Breyfogle, III, James M. Cupello, Becki Meadows, Managing Six Sigma:A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success, John Wiley & Sons, 2000
5. James P. Womack, Daniel T.Jones, Lean Thinking, Free Press Business, 2003

CO's- PO's & PSO's MAPPING

CO's	PO's			PSO's		
	1	2	3	1	2	3
1	-	3	3	-	-	2
2	-	3	3	-	-	2
3	2	3	3	-	-	2
4	3	-	3	2	3	2
5	2	-	3	2	3	2
Avg	**2.33**	**3**	**3**	**2**	**3**	**2**

1-low, 2-medium, 3-high, '-"- no correlation

IL3152	OPERATIONS MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. Todescribe the concepts in facility planning.
2. To summarize the types of plant layout and capacity planning methods
3. To impart the knowledge about the concepts of Project management.
4. Tofamiliarize the concepts and methods in production planning and control.
5. To study the concepts in Inventory and maintenance management.

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

Plant layout types, 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, Kanban, 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

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Extend knowledge on facilities, and problems associated with them.
CO2 Compare the various capacity and layout planning models.
CO3 Illustrate the concepts of demand forecasting and project management with relevant case studies.
CO4 Explain the concepts of production planning and scheduling.
CO5 Explain the concepts of inventory and maintenance management.

REFERENCES:

1. CharyS. N, “Production and Operations Management”, SIE, TMH, 6th Edition, 2019.

2. Chase. R B, N. J. Aquilano, & F. R. Jacobs, “Operations Management – ForCompetitiveAdvantage”, SIE, TMH, 11th Edition, 2008.
3. James. B. Dilworth, “Operations Management – Design, Planning and Control for Manufacturing and Services”, McGraw HillInc. Management Series, 3rd Edition, 2000.
4. KanishkaBedi, “Production and Operations Management”, Oxford HigherEducation, 2nd Edition, 2016.
5. Lee. J. Krajewski, L. P. Ritzman, & M. K. Malhothra, “Operations Management – Process and Value Chains”, Prentice Hall Professional, 8th Edition, 2015.
6. Melnyk, Denzler,“Operations Management –A Value Driven Approach”, Irwin McGrawHill, 1996.
7. Pannererselvam, R “Production and Operations Management”,PHI, 3rd Edition, 2012.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	1	1	2	2	1	1.3
CO2	1	1	1	2	2	1	1.3
CO3	1	1	1	2	2	1	1.3
CO4	2	1	2	2	2	1	1.7
CO5	2	1	2	2	2	1	1.7
POs Average	1.4	1.0	1.4	2.0	2.0	1.0	

1 – Slight, 2 – Moderate, 3 - Substantial

QE3051 QUALITY MANAGEMENT L T P C

3 0 0 3

COURSEOBJECTIVES:

1. To Summarize the Overview of Quality
2. To Illustrate the essentials of Quality
3. To Understand and apply Selected Quality Improvement techniques
4. To gain knowledge on research and development (R&D) certification standards
5. To DevelopcomprehensiveknowledgeofQualityManagementSystemsandawards

UNIT I INTRODUCTION 9

History of Quality – Objectives and Importance of Quality Management – Contributions of Quality Gurus – Quality Information System – StrategyDevelopmentandDeployment–NeedforQualityApproachtoStrategy – Definition of Quality and its types–Distinction between product quality and service quality – TQM Framework – Barriers to TQM – Benefits of TQM.

UNIT II ESSENTIALSOFQUALITYMANAGEMENT 9

Leadership – Desirable Qualities of a Leader – Role of Leaders in Quality improvement; Customer focus – Steps of developing customer focus – Customer and management – Factors affecting customer satisfaction – Importance of customer retention – Employee Involvement – Motivation – Empowerment - Teams – Rewards and Recognition – Performance appraisal-Quality circles.

UNIT III QUALITYIMPROVEMENTTECHNIQUES 9

Continuous process improvement – The Juran Trilogy – Improvement strategies-The PDSA Cycle – Kaizen – Six Sigma – Bench Marking – Cost of Quality – Quality Function Deployment (QFD) –The role of Information Technology in Quality improvement.

UNIT IV RESEARCH AND DEVELOPMENT STANDARDS 9

Industrial Automation and Control Systems Security (IEC 62443) -(ISO 31000:2018) Risk Management - Association of Clinical Research Professionals (ACRP) - National Institute of Standards and Technology (NIST) - Good Laboratory Practice (GLP) - Good Clinical Practice (GCP) - ISO/IEC 17025:2017 - General Requirements for the Competence of Testing and Calibration Laboratories - Research Excellence Framework (REF) – Intellectual Property (IP) standards.

UNIT V QUALITY MANAGEMENT SYSTEMS AND AWARD 9

ISO 9000 Series – ISO 9001: 2015 – ISO 9000 Vs Baldrige Award – Malcolm Baldrige National Quality Award- Rajiv Gandhi National Quality Award - Quality 5 STAR rating system-ISO 13485:2016 - Medical Devices Quality Management System – Environmental Management System (EMS):Introduction—ISO 14000 Series Standards (ISO 14001, 14004, 14031, 19011) —IATF 16949 Automotive Quality Management System – Benefits of EMS.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

The students will be able to

CO1. Recognition of the importance of Quality

CO2. Acquiring Essentials of Quality

CO3. Application of Quality Improvement tools

CO4. Research and Development standards

CO5. Comprehensive Quality Management System

REFERENCES:

1. Dale H. Besterfiled, Carol B. Michna, Glen H. Besterfield, Mary B. Sacre, Hemant Urdhwareshe and Rashmi Urdhwareshe, “TotalQualityManagement”, PearsonEducation Asia, Revised Third Edition, Indian Reprint, Sixth Impression, 2013
2. K.Krishnaiah,“AppliedStatisticalQualityControlandImprovement”,PHILearning,NewDelhi–2014
3. Panneerselvam. R and Siva Sankaran. P,” QualityManagement”,PHILearning,NewDelhi–2014
4. Summers,C.S.,QualityManagement:CreatingandSustainingOrganizationeffectiveness,Prentice–HallofIndia,NewDelhi,2005.
5. Dinesh Kumar Khamari, Quality Management System Manual IATF 16949: 2016., 2020.
6. Research and Development Evaluation in the Aerospace and Defense Industry & quot; by Matthew Z. Liberatore and Brian J. Lunday
7. ISO 13485:2016 - A Complete Guide to Quality Management in the Medical Device Industry & quot; by Itay Abuhav
8. Good Laboratory Practice: A Question & Answer Reference Guide & quot; by David S. Loseke
9. ISO 9001:2015 for Small Businesses & quot; by Ray Tricker

CO’s- PO’s & PSO’s MAPPING

CO’s	PO’s			PSO’s		
	1	2	3	1	2	3
1	-	3	-	-	-	-
2	-	-	-	-	-	3
3	3	-	-	-	3	-
4	-	2	-	-	3	2
5	-	-	3	-		3
Avg	3	2.5	3	-	3	2.6

1-low, 2-medium, 3-high, ‘-“- no correlation

MS3051HUMAN RESOURCE MANAGEMENT **L T P C**

3 0 0 3

COURSE OBJECTIVES:

To introduce and explain the functions, recruitment, selection, and training methods of Human Resource Management, as well as to examine the ideas of remuneration, labour relations, employee security, and quality assurance in HRM.

UNIT I HUMAN RESOURCE FUNCTION 9

Human Resource (HR) management – Meaning and importance- Difference between personnel and HR management – Changing environments of HRM – Strategic human resource management – Use of HRM to create competitive advantage – Trends in HRM – Organization of HR department – Role of HR Managers. Strategic Management Process and Human Resource Management. Evolution and growth of Personnel Management in India. Human Resources Policies: Need, type and Scope.

UNIT II RECRUITMENT & SELECTION 9

Job analysis: Methods – Job specification and description – HR and the responsive organization – IT and computerized skill inventory – Computer-based job analysis: HR planning and forecasting – Building employee commitment – Recruitment and selection process – Promotion from within – Developing and using application forms – IT and recruiting on the internet – Employee testing & selection: Selection process, basic testing concepts, types of test and validation – Work samples & simulation, selection techniques, interview, common interviewing mistakes – Designing & conducting the effective interview, competency mapping, computer-aided interview – Evaluation of selection process. Functions of Human Resources Management from Procurement to Separation – Placement, Induction, Transfers, Promotions Disciplinary actions, Termination of services.

UNIT III TRAINING & DEVELOPMENT 9

Orienting the employees, training process, need for training, training techniques, special purpose training, training via the internet – Training evaluation – Developing Managers: Management development – Responsive managers - On-the-job and off-the-job development techniques – Using HR to build a responsive organization – Use of CD-ROMs – Key factor for success – Performance appraisal: Tools, feedback, appraisal interviews – Performance appraisal in practice – Career planning and development – Managing promotions and transfers. MBO as a method of appraisal, job evaluation, criteria for promotions and job enrichment.

UNIT IV COMPENSATION & MANAGING QUALITY 9

Establishing pay plans: Basics of compensation – Factors determining pay rate – Current trends in compensation – Job evaluation – Pricing managerial and professional jobs – Computerized job evaluation – How to create a Market-Competitive Pay Plan-Pay for performance and financial incentives: Money and motivation – Incentives for operations employees and executives – Organization-wide incentive plans – Practices in Indian organizations – Services benefits: Statutory benefits – Non-statutory (voluntary) benefits – Insurance benefits – Retirement benefits and other welfare measures to build employee commitment. Personal services and family-friendly benefits flexible benefits programs.

UNIT V
LABOUR RELATIONS & EMPLOYEE SECURITY 9

Implications of labour legislations – Employee health – Auditing HR functions, Future of HRM function. Workplace health hazards: problems and remedies-occupational security and safety.

Total: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able

CO1: To obtain knowledge of the roles and functions of Human resource management.

CO2: To become familiar with the various techniques used in the recruitment and selection process**.**

CO3: To understand the concepts of training methods and development techniques.

CO4: To understand the concepts of compensation and benefits.

CO5: Torecognize the various employee relations and security.

REFERENCES:

1. BiswajeetPattanayak, “Human Resource Management”, 6th Edition, PHI, 2020.
2. David A. DeCenzo; Stephen P. Robbins; Susan L. Verhulst, “Fundamentals of human resource management”, 12th Edition, John Wiley & Sons, Inc., 2016.
3. Arthur Diane, “Recruiting, Interviewing, Selecting, and Orienting New Employees”, 6th Edition, Thomas Nelson, 2019.
4. Gary Dessler&BijuVarkkey, "Human Resource Management", 16th Edition, Pearson Education, 2020.
5. Julie Beardwell& Amanda Thompson, “Human Resource Management: A Contemporary Approach, 8th edition, Published by Pearson, 2017.
6. John Stredwick, “An Introduction to Human Resource Management”, Routledge / Taylor & Francis 2014.
7. Robert L. Mathis, John H. Jackson, Sean R. Valentine, Patricia Meglich, “Human Resource Management”, 12th Edition, Cengage Learning, 2016.

CO	**PO**					
	1	**2**	**3**	**4**	**5**	**6**
1	2	2			1	
2	3	2	2		2	
3	3	2	1	3		2
4	2	2				
5	3	3		2		
Avg	2.6	2.2	1.5	2.5	1.5	2

		L	T	P	C
MN3009	**MECHANICAL BEHAVIOUR OF MATERIALS AND THEIR MEASUREMENTS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES:

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

1. To study about the elastic deformation of the materials
2. To describe about the plastic deformation of the materials
3. Tostudy the typical techniques of evaluation of fracture and fracture mechanics of materials.
4. To familiarize Fatigue testing methods.
5. To summarize the Creep testing methods.

UNIT – I ELASTIC DEFORMATION 9

Stresses, Strains and Displacements – Determination of Principal Values of Stresses and Strains in 2-D & 3-D – Maximum Shear Stress – Strain Measurement Using Mechanical extensometers- Strain gauge, principle, types, performance and uses- Photo elasticity – Principle and applications -Moire Fringe - Digital Image correlation- Load cells/ Force sensors. Characteristics of Structural Vibrations – Linear Variable Differential Transformer (LVDT) – Transducers for velocity and acceleration measurements- Calibration of sensors.

UNIT – II PLASTIC DEFORMATION 9

Dislocation theory - dislocations in the FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning- Yield Criterions- Holography – use of laser for structural testing – Brittle coating

UNIT – III FRACTURE AND FRACTURE MECHANICS 9

Types of fracture, Basic mechanisms of ductile and brittle fracture, Griffith's theory of brittle fracture, Orowan's modification. Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, Determination of DBTT. Fracture mechanics- Introduction, Modes of fracture, Defect characterization – Inspection of cracks and other flaws- Non destructiveevaluation(NDE) - Acoustic Emission Technique – Ultrasonic – Pulse-Echo - Fractography - Stress intensity factor, Strain energy release rate, Fracture toughness and Determination of KIC, Introduction to COD, J integral.

UNIT – IV FATIGUE 9

Stress cycles, S-N curves, Effect of mean stress, Factors affecting Fatigue, Structural changes accompanying fatigue, Cumulative damage, HCF / LCF, thermo mechanical fatigue, application of fracture mechanics to fatigue crack propagation, fatigue testing machines- Paris Equation, NDE – Eddy Current Testing – X-Ray Radiography- Residual life prediction under Fatigue.

UNIT – V CREEP 9

Creep curve, Stages in creep curve and explanation, Structural changes during creep, Creep mechanisms, Metallurgical factors affecting creep, High temperature alloys, Stress rupture testing, Creep testing machines, Parametric methods of extrapolation. Deformation Mechanism Maps - high temperature: strain gages- load cells- temperature sensors.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Explain the elastic behaviour of various materials.
CO2 Summarize essential information about plastic deformation of the materials.
CO3 Compare the fracture types and mechanisms involved.
CO4 Interpret typical test results and procedures for Fatigue testing of materials.
CO5 Identify typical test results and procedures for Creep testing of materials.

REFERENCES:

1. Thomas H.Courtney, " MechanicalBehaviour of Materials", McGraw-Hilll, Boston,2nd edition, 2000.
2. Sadhu Singh, "Experimental Stress Analysis", Khanna Publishers, New Delhi, 2009.
3. Dieter, G. E., "Mechanical Metallurgy", McGraw-Hill Co., SI Edition, 1995
4. Ted L. Anderson, "Fracture Mechanics: Fundamentals and Applications", CRC Taylor and Francis, 4th Edition, 2017
5. E.O. Doebelin, 'Measurement Systems – Application and Design', Tata McGraw Hill, 2003.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	1	2	2	1	1.5
CO2	2	1	1	2	2	1	1.5
CO3	2	1	1	2	2	1	1.5
CO4	2	1	1	2	2	1	1.5
CO5	2	1	1	2	2	1	1.5
POs Average	2.0	1.0	1.0	2.0	2.0	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3010 ADVANCED FEA AND CFD L T P C

3 0 0 3

COURSE OBJECTIVES:

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

1. Gain an understanding of Finite Element Analysis and its application in solving problems involving plate and shell elements.
2. Comprehend the concepts of Finite Element Analysis and its utilization in solving problems that involve geometric and material nonlinearity
3. Apply solution techniques to effectively solve dynamic problems using Finite Element Analysis
4. Analyse the role of numerical modelling in the fields of heat transfer, fluid flow, and combustion, and evaluate its significance in solving complex problems.
5. Develop finite volume discretized forms of the governing equations for diffusion processes, demonstrating the ability to create computational models for heat transfer and fluid dynamics problems

UNIT – I BENDING OF PLATES AND SHELLS 9

Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements –Degenerated shell elements- Application and Examples.

UNIT – II NON-LINEAR PROBLEMS 9

Introduction – Iterative Techniques – Material non-linearity – Elasto Plasticity – Plasticity – Visco Plasticity – Geometric Nonlinearity – large displacement Formulation –Solution procedure Application in Metal Forming Process and Contact Problems.

UNI – III DYNAMIC PROBLEM 9

Direct Formulation – Free, Transient and Forced Response – Solution Procedures – Eigen Solution-Subspace Iterative Technique – Response analysis-Houbolt, Wilson, Newmark – Methods – Explicit & Implicit Methods- Lanchzos, Reduced method for large size system equations.

UNIT – IV GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 9

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretization techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test

UNIT – V CONVECTION-DIFFUSION PROCESSES: FINITE VOLUME METHOD 9

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Apply concept of Finite Element Analysis to solve problems involving plate and shell elements

CO2 Apply concept of Finite Element Analysis to solve problems involving geometric and material nonlinearity

CO3 Formulate solution techniques to solve dynamic problems Apply concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems

CO4 Analyse the governing equations and boundary conditions.

CO5 Analyse various discretization techniques for both steady and unsteady diffusion problems.

REFERENCES:

1. Bathe K. J, “Finite Element Procedures in Engineering Analysis”, Prentice Hall, 2nd edition, 2019.
2. Logan.D. L, “A first course in Finite Element Method”, Cengage Learning, enhanced 6th Edition, 2023.
3. ReddyJ.N, “An Introduction to Nonlinear Finite Element Analysis”, Oxford,2nd Edition, 2021.
4. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, “Concepts and Applications of Finite Element Analysis”, Wiley Student Edition, 4th Edition, 2019.
5. Tirupathi R. Chandrupatla and Ashok D. Belegundu, “Introduction to Finite Elements inEngineering”, International Edition, Pearson Education Limited, 5th Edition, 2022.
6. Zienkiewicz, O.C., Taylor, R.L. and Zhu.J.Z., “The Finite Element Method: Its Basis and Fundamentals”, Butterworth-Heinemann, 7th Edition, 2014.
7. Versteeg and Malalasekera, N, “An Introduction to computational Fluid Dynamics the Finite Volume Method,” Pearson Education, Ltd., Second Edition, 2013.
8. Ghoshdastidar, P.S., “Computer Simulation of Flow and Heat Transfer”, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	2	1	3	2	2.0
CO2	3	1	2	1	3	2	2.0
CO3	3	1	2	1	3	2	2.0
CO4	3	1	2	1	3	2	2.0
CO5	3	1	2	1	3	2	2.0
POs Average	3.0	1.0	2.0	1.0	3.0	2.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

CI3052 DESIGN FOR MANUFACTURING AND ASSEMBLY

L	T	P	C
3	0	0	3

OBJECTIVES:

1. To teach manufacturing issues that must be considered in the mechanical engineering design process.
2. To Discuss on tools and methods to facilitate development of manufacturable mechanical designs.
3. To make the students to Understand the importance of Assembly, Reliability and Quality for improving design process approach.

UNIT I INTRODUCTION 9

DFMA: overview –Product Design- Process-Design -Process overview: Conceptual and configuration design of products and assemblies, criteria and concepts in design, Introduction to limits, fits and Tolerances Dimensional management & tolerance analysis: GD & T, Datum features, stockup Analysis-Need Identification and Problem Definition- Concept Generation and Evaluation-Embodiment Design.

UNIT II SELECTION OF MATERIALS AND SHAPES 9

Overview of engineering materials -standards for materials selection - -Physical and Mechanical Properties of Engineering Materials- Selection of Materials-Case Studies -Selection of Shapes-Co-Selection of Materials and Shapes- Effect of composition, processing and structure on material Properties-Case-Studies.

UNIT III SELECTION OF MANUFACTURING PROCESSES 9

Review of Manufacturing Processes- The concept of manufacturability- Limitations of manufacturing -Design for Casting- Various Casting process, Defects in casting and its remedial measure, recommendation for achieving good quality casting Design -Design for Bulk Deformation Processes-Design for Sheet Metal Forming Processes-Design for Machining- Advantages and disadvantages and design guide line of parts for machining. Design for Powder Metallurgy-Design for Polymer Processing-Co-selection of Materials and Processes-Case Studies Design of jigs and fixtures Mathematical modeling and Finite Element Analysis-Simulation -Rapid prototyping

UNIT IV DESIGN FOR ASSEMBLY 9

Review of Assembly Processes- Design for Welding- Defects in welding, methods for rectification -Design for Brazing and Soldering: Design recommendation for brazing and soldering for good quality joints - Design for Adhesive Bonding-Design for Joining of Polymers

UNIT V DESIGN FOR RELIABILITY AND QUALITY 9

Reliability theory and design for-Failure Mode and Effect Analysis- Design for Heat Treatment-Case Studies-Design for corrosion resistance, Design for wear Resistance-Design for Quality-Approach to Robust Design-Design for Optimization Design for safety Design for environment

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to

CO 1: Understand how to formulate the need analysis leading to definition of the design problem and to convert design problem leading to embodiment design.

CO 2: Identify the suitability of materials application and manufacturing considerations

CO 3: Select manufacturing process and to consider design as per the process adopted for the design problem.

CO 4: Apply the principles of assembly to minimize the assembly time.

CO 5: Analyze and apply the concept of reliability and quality in the product design process.

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	3	3	3	3
CO2	3	1	3	3	3	3
CO3	3	1	3	3	3	3
CO4	3	1	3	3	3	3
CO5	3	1	3	3	3	3

REFERENCES:

1. Geoffrey Boothroyd, Peter Dewhurst, and Winston A. Knight, “Product Design, for Manufacture, and Assembly”, 3rd Edition, CRC Press., United States,2011, ISBN 9781420089271.
2. Peck H., “Designing for manufacture”, Sir Isaac Pitman & Sons Ltd., United States 1973.
3. James G. Bralla, “Design for manufacturability handbook”, McGraw Hill., United States, 1999,
4. David M. Anderson, “Design for manufacturability “, CRC Press., United States, 2014, ISBN 9781482204926.
5. G. Dieter, Engineering Design - a materials and processing approach, 4th Edition, McGraw Hill, NY, 2009.
6. Molloy O., Tilley S., and Warman E., “Design for Manufacturing and Assembly Concepts, architectures and implementation”, Springer., United Kingdom, 1998, Reprint 2012, ISBN: 978- 1461376507.
7. M. F. Ashby and K. Johnson, Materials and Design - the art and science of material selection in product design, Butterworth Heinemann, 2003.

MN3051 CONCEPTS IN PRODUCT DEVELOPMENT

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

1. Apply concurrent engineering principles in structuring work and deploying teams effectively in product development projects.
2. Analyse the role of customer involvement throughout the stages of the Product Life Cycle (PLC).
3. Utilize analysis tools such as Failure Mode and Effects Analysis (FMEA) to identify and mitigate potential risks in product design.
4. Assess the significance of intellectual property rights (IPR) in protecting new product innovations and conducting patent searches to ensure compliance.
5. Conduct quantitative and qualitative analysis to estimate future cash inflows and outflows in product development projects.

UNIT I PRODUCT DEVELOPMENT PROCESS & METHODOLOGIES 9

Integrated Product development process - Conceive – Specification, Concept design, Design - Detailed design, Validation and analysis (simulation), Tool design, realize – Plan manufacturing, Manufacture, Build/Assemble, Test (quality check), Service - Sell and Deliver, Use, Maintain and Support, Dispose. Bottom-up design, Top-down design, Front loading design workflow, Design in context, Modular design. Concurrent engineering - work structuring and team Deployment - Product and process systemization - problem, identification and solving methodologies. Product Reliability, Mortality Curve. Design for Manufacturing, Design for Assembly. Design for Six Sigma.

UNIT II INTRODUCTION TO PRODUCT LIFE CYCLE ENVIRONMENT 9 Background, Overview, Need, Benefits, Concept of Product Life Cycle. Components/Elements of PLM, Emergence of PLM, Significance of PLM, Customer Involvement. Product Data and Product Workflow, Company's PLM vision, The PLM Strategy, Principles for PLM strategy, preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, Change Management for PLM, Transfer file, Database integration, System roles ERP, CAD, Configurators, EAI, PLM and Service Industry, PLM and E- Business and PLM Softwares, Tools.

UNIT III PRODUCT MODELLING AND ANALYSIS TOOLS 9

Product Modelling - Definition of concepts - Fundamental issues - Role of Process chains and product models -Types of product models - model standardization efforts-types of process chains - Industrial demands. Design for manufacturing - machining - casting and metal forming - optimum design - Design for assembly and disassembly - probabilistic design concepts - FMEA - QFD - Taguchi Method for design of experiments -Design for product life cycle. Estimation of Manufacturing costs, Reducing the component costs and assembly costs, Minimize system complexity.

UNIT IV PROJECT SELECTION, EVALUATION AND IPR 9

Collection of ideas and purpose of project - Selection criteria - screening ideas for new products (evaluation techniques). New Product Development Research - Patents - Patent search - Patent laws - International code for patents - Intellectual property rights (IPR). Design of proto type - testing - quality standards - marketing research - Understanding Customer Needs, Establishing Product Function - Product Teardown and Experimentation, Benchmarking and Establishing Engineering Specifications, Product Architecture.

UNIT V PRODUCT DEVELOPMENT ECONOMICS 9 Elements of Economics analysis - Quantitative and qualitative analysis-Economic Analysis process-Estimating magnitude and time of future cash inflows and out flows Sensitivity analysis-Project trade-offs-Trade-offs rules-Limitation of quantitative analysis- Influence of qualitative factors on project success.

COURSE OUTCOMES

Upon successful completion if the course, students should be able to

1. Apply problem-solving strategies and methodologies to address challenges encountered during the product development process.
2. Evaluate the impact of customer involvement at different stages of the product life cycle and propose strategies for effective customer engagement.
3. Apply various product modelling techniques, such as CAD software and simulation tools, to create and optimize product designs.
4. Apply intellectual property rights (IPR) principles and conduct patent searches to protect and manage new product innovations.
5. Analyse and interpret quantitative and qualitative data to assess the economic viability of product development projects.

REFERENCES

1. Grieves, Michael. Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303
2. Product Life Cycle Management - by Antti Saaksvuori, AnselmiImmonen, Springer, 1st Edition (Nov.5, 2003)
3. Stark, John. Product Lifecycle Management: Paradigm for 21st Century Product Realisation, Springer-Verlag, 2004. ISBN 1852338105
4. Karl T. Ulrich and Steven D. Eppinger "Product Design and Development"
5. John Stark "Product Lifecycle Management: Volume 1 - 21st Century Paradigm for Product Realisation"
6. Gerhard Pahl, Wolfgang Beitz, and JörgFeldhusen "Engineering Design: A Systematic Approach"
7. Michael N. Kennedy "Product Development for the Lean Enterprise: Why Toyota's System is Four Times More Productive and How You Can Implement It"
8. Anil Mital, Anoop Desai, and Anand Subramanian "Product Development: A Structured Approach to Consumer Product Development, Design, and Manufacture"
9. Michael Pfeifer "Design for Manufacturability and Statistical Design: A Constructive Approach"
10. Richard Stim "Intellectual Property: Patents, Trademarks, and Copyrights"
11. Marc Annacchino "New Product Development: Successful Innovation in the Marketplace"
12. Niall M. Fraser "Engineering Economics: Financial Decision Making for Engineers"

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	2	1	2	2	1	1
2	2	1	2	2	1	1
3	2	1	2	2	1	1
4	2	1	2	2	1	1
5	2	1	2	2	1	1
Avg	**2**	**1**	**2**	**2**	**1**	**1**

MR3051 MULTI-BODY DYNAMICS AND CONTROL

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

1. To understand the importance of dynamics in analyzing the behavior of mechanical systems.
2. To develop proficiency in using computational methods for dynamic analysis of multibody systems.
3. To apply stability analysis techniques to assess the stability of nonlinear systems.
4. To characterize the behavior of nonlinear systems using phase plane analysis and describing function.
5. To design control strategies to achieve desired performance in nonlinear mechanical systems.

UNIT I INTRODUCTION TO DYNAMICS 9

Importance of Multibody Dynamics - Particle Mechanics - Rigid Body Mechanics - Deformable Bodies - Constrained Motion- -Kinematics - Rotation - Translation - Velocity-Acceleration Equations – Mechanics of Deformable Bodies - Floating Frame Reference Formulation – Inertia - Generalized Forces - Equation of Motions - Multi Body Systems - Sub Systems - Friction and Spring Nonlinear Model - Nonlinear Dynamic Equations Formulation

UNIT II COMPUTATIONAL METHODS FOR DYNAMIC ANALYSIS 9

Jacobian Matrix - Newton-Raphson Method - Nonlinear Kinematic Constrain Equation – System Mass Matrix - External and Elastic Forces - Acceleration Vector – Lagrangean Multiplier - Langrage's Equation – Kinetic Energy – Hamilton Equation - Hamilton vector Field- Euler - Langrage Equation- Generalized Reaction Forces – State Vector and Equation Formulation.

UNIT III NONLINEAR SYSTEMS AND CONCEPTS 9

Linear Time Varying and Linearization – Input and Output Stability - Lyapunov Stability Analysis – Asymptotic Stability - Popov's and Circle Criterion - Perturbed System – Chaos – Periodic Orbits- Index theory and Limit Cycle – Centre Manifold Theory- Normal Forms-Nonlinear analysis- Poincare Maps - Bifurcations – Maps - Vector Fields - Methods – Control System Design using Lyapunov's Direct Method.

UNIT IV SYSTEM CHARACTERIZATION 9

Stability, Controllability, Observability - Phase Plane Analysis - Phase Portrait - Limit Cycle - Describing Function - Assumption – Limit Cycles.

UNIT V CONTROL OF NONLINEAR MECHANICAL SYSTEMS 9

Double Inverted Pendulum – Nonlinear Machineries – Robots - Suspension System - Aircraft.

TOTAL 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Describe the fundamental concepts and principles of dynamics in mechanical systems.

CO2 Apply computational methods for analyzing and solving dynamic problems in multibody systems.

CO3 Analyze and evaluate the stability and behavior of nonlinear systems using mathematical techniques.

CO4 Characterize and assess the properties of mechanical systems, such as stability, controllability, and observability.

CO5 Design and implement control strategies to achieve desired performance in nonlinear mechanical systems.

REFERENCES

1. Ahmed A. Shabana, "Dynamics of Multibody Systems", Cambridge University Press, fifth edition, 2020.
2. Brian L. Stevens, Frank L. Lewis, "Aircraft Control and Simulation", Wiley India Pvt Ltd, third Edition, 2016.
3. Hasan Khalil, "Nonlinear Systems and Control", Prentice Hall, 2018.
4. MahmutReyhanoglu, "Dynamics and Control of a Class of Under Actuated Mechanical Systems", IEEE Transactions on Automatic Control, 44(9), 2013.
5. Stephen Wiggins, "Introduction to Applied Nonlinear Dynamics System and Chaos", Springer-Verlag, Fouth Edition, 2018.
6. Wei Zhong and Helmut Rock, "Energy and Passivity Based Control of the Double Inverted Pendulum on a Cart", IEEE, 2019.

COs	POs					
	1	2	3	4	5	6
1	1	1	2	1	-	-
2	2	1	2	1	3	-
3	2	1	1	1	3	-
4	1	1	2	1	1	-
5	2	1	1	1	2	-
Avg	**1.6**	**1**	**1.6**	**1**	**1.8**	**-**

MN3052 MECHATRONICS IN MANUFACTURING

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

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

1. To Understand and apply the principles of mechatronics in modern manufacturing
2. To Develop proficiency in selecting and integrating sensors, transducers, drives, and actuators for mechatronic systems
3. To Design and optimize manufacturing processes using mechatronic principles and techniques
4. To Gain practical skills in programming and interfacing microcontrollers for controlling mechatronic systems
5. To Analyze and evaluate the performance of mechatronic systems in manufacturing operations for continuous improvement

UNIT I INTRODUCTION TO MECHATRONICS IN MODERN MANUFACTURING 9

Introduction to Process Parameters in Conventional Manufacturing – Assembly – Inspection – Transportation - Introduction to basic elements of Mechatronics Systems- 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 9

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 9

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 IV MICROPROCESSORS AND MICROCONTROLLERS 9

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

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to

CO1 Recall and identify key concepts in mechatronics for modern manufacturing.

CO2 Describe the principles and relationships of mechatronic system elements in manufacturing processes.

CO3 Apply knowledge of sensors, transducers, drives, and actuators to design and troubleshoot mechatronic systems.

CO4 Analyze and evaluate the performance of mechatronic components for process optimization.

CO5 Design and integrate mechatronic systems for manufacturing automation.

REFERENCES:

1. Bolton .W.,"Mechatronics" ,Pearson Education Limited, 5th Edition, 2011.
2. Mazidi. M.A and Mazidi .M.J., MCkinlay.R.D, "The 8051 Microcontroller and Embedded Systems Using Assemblyand C", Pearson India, 2nd Edition, 2008.
3. Patranabis D., "Sensor and Actuators", Prentice Hall of India Pvt Ltd., 2nd edition 2005.
4. Vijayaraghavan G.K., BalasundaramM.S , Ramachandran K.P. , Mechatronics: IntegratedMechanical Electronic Systems, Willey, 2008.
5. John P. Bentley., "Principle of Measurement systems", Pearson Prentice Hall, Fourth edition,2005.
6. K. Ogata, "Modern Controls Engineering ", Prentice Hall of India Pvt. Ltd., New Delhi, 2005.

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	2	1	1	1	-	1	1.2
CO2	2	1	2	1	1	1	1.3
CO3	2	1	2	1	1	2	1.5
CO4	2	1	2	1	1	2	1.5
CO5	2	1	2	1	1	2	1.5
POs Average	2.0	1.0	1.8	1.0	1.0	1.6	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3011	FACTORY AUTOMATION	L	T	P	C
		3	0	3	3

COURSE OBJECTIVES:

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

1. To understand the importance of automation in industry and various industrial standard sensors and process parameters to control the production process.
2. To learn PLC hardware and practice PLC programming and simulation in real systems.
3. To get knowledge on industrial standard data communication protocols, SCADA, centralized and decentralized control.
4. To get introduced to factory layout, Total Integrated Automation on factory and Industry 4.0.
5. To get exposure on building automation using sensors, controllers and actuators.

UNIT I INDUSTRIAL INSTRUMENTATION AND CONTROL 9

Introduction and Need for Automation - Instrumentation System for Measurement of Process Parameters – Overview on Flow, Level, Pressure, Temperature, Speed, Current and Voltage Measurements – Proximity and Vision Based Inspection Systems – Process Control Systems – Continuous and Batch Process – Feedback Control System Overview

UNIT II PROGRAMMABLE LOGIC CONTROLLER 9

Fundamentals of Programmable Logic Controller - Functions of PLCs - Features of PLC - Selection of PLC - Architecture – Basics of PLC Programming - Logic Ladder Diagrams – Communication in PLC – Programming Timers and Counters – Data Handling –PLC modules – Advanced PLC.

UNIT III DATA COMMUNICATION AND SUPERVISORY CONTROL SYSTEMS 9

Industrial Data Communications - Fiber Optics – Modbus – HART – Device Net – Profibus – Fieldbus – Introduction to Supervisory Control Systems – SCADA - Distributed Control System (DCS) – Safety Systems – Man-Machine Interfaces – Total Integrated Automation (TIA)

UNIT IV SYSTEMS FOR FACTORY AUTOMATION 9

Factory Layout – Tools and Software Based Factory Modelling – Case Study on Automated Manufacturing Units, Assembly Unit, Inspection Systems and PLC Based Automated Systems – Introduction to Factory Automation Monitoring Software – Building Automation System – Software

UNIT V SMART TECHNOLOGIES FOR INDUSTRIAL 4.0 9

Industry 4.0 – Challenges in Industry 4.0 – Big Data – Characteristics of big data – Artificial Intelligence – Machine to Machine Technologies – IoT-Digitization – Digital Twin

TOTAL 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

- **CO1** State the need of identifying the control parameters, sensors, controllers, communication and role of advanced technologies in automating the industry.
- **CO2** Describe the operation of sensors, instrumentation, Logic controller, communication protocol, factory setup and smart technologies.
- **CO3** Design and simulate system layout develop logic program
- **CO4** Implement the selected sensor, protocol and logic in controller to automate an application.
- **CO5** Create industry model and simulate by varying the parameters to do analysis on statistical and management data of the plant.

REFERENCES

1. Frank D, Petruzella, “Programmable Logic Controller” McGraw – Hill Publications, 2016.
2. Lucas, M.P., “Distributed Control System”, Van Nastrand Reinhold Company, 1986.
3. Mackay S., Wrijut E., Reynders D. and Park J., “Practical Industrial Data Networks Design, Installation and Troubleshooting”, Newnes Publication - Elsevier, 2004.
4. Patranabis. D, “Principles of Industrial Instrumentation”, Tata McGraw-Hill Publishing Ltd.2nd edition, 2016.
5. Shengwei Wang, “Intelligent Buildings and Building Automation”, Routledge Publishers, 2009.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	1	1	2	1	2	1.3
CO2	1	1	1	2	1	2	1.3
CO3	2	1	2	2	2	1	1.6
CO4	2	1	2	2	2	1	1.6
CO5	2	1	2	2	1	1	1.5
POs Average	1.6	1	1.6	2.0	1.4	1.4	
1 – Slight, 2 – Moderate, 3 - Substantial							

MR3052 DIGITAL TWIN AND INDUSTRY 5.0

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

1. To understand the fundamental principles and concepts of digital twin technology.
2. To apply digital twin techniques to analyze and optimize complex systems.
3. To develop skills in designing and implementing digital twin models for real-world applications.
4. To evaluate the benefits and limitations of digital twin technology in various industries.
5. To critically analyze and interpret data obtained from digital twin simulations.

UNIT I INTRODUCTION 9

Digital twin – Definition, types of Industry and its key requirements, Importance, Application of Digital Twin in process, product, service industries, History of Digital Twin, DTT role in industry innovation, Technologies/tools enabling Digital Twin – Virtual CAD Models – control Parameters- Real time systems – control Parameters – Handshaking Through Internet – cyber physical systems

UNIT II DIGITAL TWIN IN A DISCRETE INDUSTRY 9

Basics of Discrete Industry, Trends in the discrete industry, control system requirements in a discrete industry, Digital Twin of a Product, Digital Thread in Discrete Industry, Data collection & analysis for product & production improvements, Automation simulation, Digital Enterprise

UNIT III DIGITAL TWIN IN A PROCESS INDUSTRY 9

Basics of Process Industry, Trends in the process industry, control system requirements in a process industry, Digital Twin of a plant, Digital Thread in process Industry, Data collection and analysis for process improvements, process safety, Automation simulation, Digital Enterprise

UNIT IV INDUSTRY 5.0 9

Industrial Revolutions, Industry 5.0 – Definition, principles, Application of Industry 5.0 in process & discrete industries, Benefits of Industry 5.0, challenges in Industry 5.0, Smart manufacturing, Internet of Things 5.0, Industrial Gateways, Basics of Communication requirements – cognitive systems 5.0

UNIT V ADVANTAGES OF DIGITAL TWIN 9

Improvement in product quality, production process, process Safety, identify bottlenecks and improve efficiency, achieve flexibility in production, continuous prediction and tuning of production process through Simulation, reducing the time to market.

TOTAL :45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Recall and explain the key principles and concepts of digital twin technology.
CO2 Apply digital twin techniques to model and simulate complex systems.
CO3 Design and implement digital twin models for specific applications.
CO4 Evaluate the effectiveness of digital twin technology in improving system performance and efficiency.
CO5 Analyze and interpret data generated from digital twin simulations to make informed decisions.

REFERENCES

1. Alp Ustundag and EmreCevikcan, “Industry 4.0: Managing the Digital Transformation”, Springer Series in Advanced Manufacturing., Switzerland, 2018
2. Andrew Yeh Chris Nee, Fei Tao, and Meng Zhang, “Digital Twin Driven Smart Manufacturing”, Elsevier Science., United States, 2019
3. UthayanElangovan, Industry 5.0: The Future of the Industrial Economy, CRC Press, 2022.
4. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, Apress., United States ,2015.
5. Christoph Jan Bartodziej, “The Concept Industry 4.0 an Empirical Analysis of Technologies and Applications in Production Logistics”, Springer Gambler., Germany, 2017.
6. Ibrahim Garbie, “Sustainability in Manufacturing Enterprises, Concepts, analyses and assessments for Industry 4.0”, Springer., Switzerland, 2016.
7. Ronald R. Yager and Jordan PascualEspada, “New Advances in the Internet of Things”, Springer., Switzerland, 2018
8. Ulrich Sendler, “The Internet of Things, Industries 4.0 Unleashed”, Springer., Germany, 2018

COs	POs					
	1	**2**	**3**	**4**	**5**	**6**
1	1	1	2	1	1	2
2	1	1	2	2	1	2
3	1	1	3	2	1	2
4	2	1	2	1	1	2
5	1	1	1	2	1	2
Avg	**1.2**	**1**	**2**	**1.6**	**1**	**2**

MR3251 **INDUSTRIAL ROBOTICS** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

1. To know the basic terminologies, classification, configurations and components of serial manipulator.
2. To understand the mechanical design and robot arm kinematics
3. To learn and understand the various linear control techniques on manipulators
4. To learn and understand the various non-linear control techniques on manipulators
5. To learn the robot programming and demonstrate the robot in various applications

UNIT I INTRODUCTION TO SERIAL MANIPULATORS 9

Types of Industrial Robots, Definitions – Classifications Based on Work Envelope – Generations Configurations and Control Loops - Coordinate Systems – Need for Robot – Basic Parts and Functions – Specifications – Robotic Sensor - Position and Proximity's Sensing – Tactile Sensing – Sensing Joint Forces.

UNIT II MECHANICAL DESIGN OF ROBOT SYSTEM 9

Robot Motion – Linkages and Joints – Mechanism – Method for Location and Orientation of Objects - Kinematics of Robot Motion – Direct and Indirect Kinematics Homogeneous Transformations – D-H Transformation – Drive Systems – End Effectors – Types, Selection, Classification and Design of Grippers – Gripper Force Analysis.

UNIT III ROBOT DYNAMICS AND TRAJECTORY PLANNING 9

Trajectory planning – joint space, Cartesian space description and trajectory planning – third order, fifth order - Polynomial trajectory planning-control overview, Dynamic equations-control - Types of Programming – Teach Pendant Programming –Robotic Cell Layouts – Inter Locks-control overview

UNIT IV MOBILE ROBOTICS 9

Wheeled Robot and Legged Robot – Architecture - Configurations and Stability - Design Space and Mobility Issues - Teleportation and Control – Localization – Navigation – AGV – AMR

UNIT V APPLICATIONS OF ROBOTS 9

Architecture and working - Manufacturing Industries - Material Handling, Assembly, Inspection. Surgical robot – Haptics technology– Space vehicle and unmanned aerial vehicle – Underwater- ROV, AUV – Robot in Nuclear industry – Humanoid Robots – special type of robots

TOTAL 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 State about fundamental concepts of manipulators and mobile robots.
CO2 Describe the robot types, robot elements, numerical computation methods and the applications
CO3 Solve the robot kinematics, dynamics, trajectory and path planning problems.
CO4 Analyze robot kinematics, dynamics, trajectory and path planning problems.
CO5 Create robot architecture, kinematic and dynamic solutions, program the robot for the given application in the environment.

REFERENCES

1. Saeed B. Niku, “Introduction to Robotics: Analysis, Control, Applications”, 3rd edition, John Wiley & sons, Inc., 2019.
2. John J. Craig, "Introduction to Robotics – Mechanics and control”, 3rd edition, Pearson Higher Education 2014.
3. K.S.Fu, Gonzalez, R.C. and Lee, C.S.G., “Robotics Control, Sensing, Vision and Intelligence”, McGraw Hill, 1987.
4. Groover,M.P., Weis,M., Nagel,R.N. and Odrey,N.G., “Industrial Robotics Technology, Programming and Applications”, Mc Graw-Hill, Int., 2012.
5. Klafter,R.D., Chmielewski, T.A. and Negin,M., “Robotics Engineering – An Integrated Approach”, Prentice-Hall of India Pvt. Ltd., 1988.
6. Kevin M Lych and frank C. Park, Modern Robotics: Mechanics, Planning and Control, Cambridge University Press, First Edition, 2017.

COs	POs					
	1	2	3	4	5	6
1	1	1	2	2	1	1
2	1	1	2	2	1	1
3	1	1	2	2	2	1
4	1	1	2	2	2	2
5	1	1	2	2	1	2
Avg	**1**	**1**	**2**	**2**	**1.4**	**1.4**

CI3054	SYSTEM SIMULATION FOR MANUFACTURING ENGINEERS	L	T	P	C
		3	0	0	3

OBJECTIVES:

1. To teach the concept of system simulation and their importance in industries and the various techniques used for generating the random numbers.
2. To discuss about the generation techniques and the use of the random numbers in simulation, tests, validity, verification, models of simulation and analysis.
3. To train the students to solve the real time problems in the discrete systems by using a simulation software.

UNIT I PREAMBLE TO SYSTEM SIMULATION 9

Systems, general systems theory, Functions/Relationship, concept of simulation, Stochastic activities, Types of Models, Principles used in Modeling, simulation as a decision-making tool, types of simulation, Important measures of performance, Advantages and disadvantages of simulation, Steps in simulation model building.

UNIT II RANDOM NUMBERS 9

Methods of generating random numbers, Desirable attributes of random numbers, manual methods, computerized methods, Pseudo random numbers and random variates, discrete and continuous random probability distributions, tests for random numbers, Need for testing random numbers, Application of random numbers in simulation models

UNIT III DESIGN OF SIMULATION 9

Problem formulation, data collection and reduction, time flow mechanism, key variables, logic flow chart, starting condition, run size, experimental design consideration, output analysis and interpretation, validation. Monte Carlo method of simulation, Manual simulation techniques

UNIT IV SIMULATION SOFTWARE AND DATA HANDLING 9

Study and selection of simulation languages, Animation based Simulation packages, Selection of Simulation language / package, Use of any one of the simulation software for simulation model building, programmable blocks, Creation of database, Data handling and reporting, terminating conditions, Interpretation of results using statistical analysis

UNIT V ADVANCED HEURISTICS AND AREAS OF APPLICATION 9

Ear deaf Analysis - Development of simulation models for Manufacturing and production systems, inventory optimization techniques, Advanced Sequencing and Scheduling problems, queuing systems - Problems,

Heuristics for scheduling - Single pass heuristics, multipass heuristics, Evolutionary Optimization techniques - Genetic algorithm, Ant Colony algorithm, Particle Swarm optimization - Case studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

At the end of the course, students will be able to

CO 1: Discuss various types of systems and identify different elements of a system to build simulation models and to use them.

CO 2: Generate, test and use random numbers in different ways.

CO 3: Explain various steps in building simulation models and how to run them for effective analysis of real life scenarios and obtain superior results.
CO 4: Develop capabilities of taking up consultancy projects and completing them successfully.
CO 5: Describe various cases in system simulation and its approaches

CO - PO MAPPING :

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	2	2	2	1
CO2	3	1	2	2	2	1
CO3	3	1	2	2	2	1
CO4	3	1	2	2	2	1
CO5	3	1	2	2	2	1

REFERENCES:

1. Banks J., Nelson B.L., Nicol D.M and Shahabudeen. P, "Discrete event system simulation", 4th edition Prentice Hall, India, 2005.
2. R. Pannerselvam and P. Senthilkumar, 'System Simulation, Modelling and languages, PHI Learning Pvt, Ltd, 2013
3. Law A.M. and Kelton W.D., "Simulation Modeling and Analysis", 2nd edition, McGraw Hill Inc. (2015), New York.
4. Geoffrey Gordon, "System Simulation", second edition, Prentice Hall, India, 2005.
5. Shannon R.E., "systems simulation – The art and Science", Prentice Hall, 1975.
6. Hardbound by Altaf Q. H. Badar,'Evolutionary Optimization Algorithms' 1st Edition 2021 , CRC Press

MN3012	BATTERY AND HYBRID ENERGY STORAGE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

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

1. To impart knowledge on types of batteries and their manufacturing as well as characteristics of hydrogen
2. To familiarize with materials involved in fabrication of Lithium batteries.
3. To introduce non lithium batteries.
4. To summarize concepts and devices for Electrical storage.
5. To learn about Fuel Cells and Hydrogen storage, principles and concepts.

UNIT – I BASICS OF BATTERIES AND HYDROGEN 9

Introduction to electrochemical energy storage and conversion devices, Fundamental of batteries – Galvanic cells - battery performance metrics, cell voltage, capacity, charging and discharging curves, Columbic efficiency, power density, energy density, and safety issues. Types of batteries – Lead Acid, Nickel – Cadmium, Zinc Manganese dioxide, – Mathematical Modelling for Lead Acid Batteries – Flow Batteries - Advantages and disadvantages, physical and chemical properties of electro-active materials, characteristics and properties of sulphuric acid, lead dioxide - constructional features, materials and manufacturing methods, SLI (Automotive) batteries, sealed lead acid or maintenance free batteries fabrication technology and testing- Hydrogen as energy source - Physical and Chemical properties - Phase Diagram - Risks, Challenges and Safety Van't Hoff plots for absorption desorption enthalpies; Gravimetric capacities; Hysteresis in cycling; Joule-Thomson Effect, Non- ideal treatment of hydrogen gas.

UNIT – II LITHIUM ION BATTERIES 9

Advanced anodes and cathodes – theoretical capacity – merits and demerits - Nanomaterials for anodes: carbon nanotubes, graphene, Sn, Al, Si, SnO_2, transition metal oxides (ex. CuO, CoO, NiO) and LTO. Nanomaterials for cathodes: $LiCoO_2$, $LiMn_2O_4$, $LiFePO_4$, and doped cathodes NMC, NMCA, NCA-. Fabrication of nanostructured $LiCoO_2$, $LiMn_2$O4, $LiFePO_4$, Si, Sn and CNTs.- Polymer and composite-based lithium polymer battery. Preparation and fabrication of solid-state electrolytes. Polymer/composite-based materials synthesis and fabrication- Manufacturing of electrolytes, electrode, assembly, packaging and testing-– constant current method, SoC& DoD estimation.

UNIT– III POST LITHIUM-ION BATTERIES 9

Metal-ion Batteries: Na^+, K^+, Mg^{2+}, Al^{3+}& Ca^{2+} ion batteries – Anodes, Cathodes, Electrolytes- Challenges & Advantages - Metal-Air Batteries: Lithium-Air, Sodium-Air, Zinc-Air batteries – Principle & components – anodes, cathodes, electrocatalysts – ORR. OER - fabrication - evaluation–merits and demerits and applications - Metal-Chalcogenides Batteries: Lithium-Sulphur, Sodium-Sulphur, Lithium-Selenium & Sodium-Selenium Batteries: Cathodes - Reaction Mechanism – Advantages - Challenges - Gravimetric & Volumetric energy density- Organic Batteries.-Manufacturing of electrolytes, electrode, assembly, packaging and testing.

UNIT – IV HYBRID ENERGY STORAGE 9

Necessity of energy storage - Role of energy storage systems – types of energy storage – comparison of energy storage technologies –. Energy storage criteria, Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems- Super capacitors: Principle of operation, device fabrication, challenges and technical review- electrical double layer model, Redox of Faradaic capacitor materials design and fabrication-, Nanostructured Carbon-based materials-ultracapacitors, redox oxides – Asymmetric/Hybrid capacitors – Supercapacitor Vs. Supercapattery.

UNIT – V HYDROGEN AND FUEL CELLS 9

Polymer electrolyte membrane (PEM) synthesis and characterization electrode, organic-inorganic membranes, and composites for bipolar plates. Role of PEM -Design and development of PEM fuel cell (PEMFC) based on Nafion, sulfonated poly (ether-ether ketone), sulfonated poly(aryl ether) for PEMFC and direct methanol fuel cell (DMFCs). Microbial Fuel Cell (MFC) – construction and performance- Membrane electrode assemblies (MEA) fabrication, catalyst layer, fuel cell supports, GDL, bipolar plates, fuel cell catalysts – precious and non- precious group catalysts- nanomaterials for low temperature fuel cells – reversible fuel cells. Fuel cell stacks and systems - fuel cells for vehicles and grid connected applications - Fuel cell and Hybrid fuel-energy storage system-Hydrogen generation - conventional methods - steam reformation - water splitting and nanotechnology - Thermodynamics and kinetics of hydrogen fuel cells- Hydrogen Storage - Physical and Chemical methods - Materials-Based Hydrogen Storage -solid state; metal organic – Zeolites – carbons – interstitial hydrides – AB_5& AB_2 compound - metal hydrides, complex hydrides and chemical hydrides - other novel methods.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Identify the performance parameters of batteries and brief on manufacturing methods and characteristics of hydrogen.

CO2 Classify and compare the various lithium based batteries.

CO3 Relate batteries besides lithium and emerging technologies

CO4 Describe the materials and devices for storing electrical energy

CO5 Explain the features of various types of Fuel Cell and concepts of Hydrogen storage.

REFERENCES:

1. Christian Glaize and Sylvie Geniès, “Lithium batteries and other electrochemical storage systems”, ISTE and Wiley, 1st Edition, 2013.
2. John Warner, “The handbook of lithium – ion battery pack design: Chemistry, components, types and terminology”, Elsevier, 1st Edition, 2015.
3. J Zhang, “Electrochemical energy: Advanced materials and technologies”, CRC press, 1st Edition, 2017.
4. Robert Huggins, “Energy Storage”, Springer, 1st Edition, 2016.
5. Alexander Gavrilyuk, “Hydrogen energy for Beginners”, Pan Stanford, publishing Pvt, Ltd, 2014.
6. Angelo Basile, Adolfo Iulianelli, “Advances in Hydrogen Production, Storage and Distribution”, Woodhead Publishers, 1st Edition, 2014.
7. AuliceScibiohM.andViswanathan B, “Fuel Cells – principles and applications’, University Press (India), 2006.

Mapping of COs with Pos							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	1	-	1	2	2	1.4
CO2	2	1	1	2	2	2	1.7
CO3	2	1	2	2	2	2	1.8
CO4	1	1	2	2	1	1	1.3
CO5	1	1	3	2	0	1	1.6
POs Average	1.4	1.0	2.0	1.8	1.8	1.6	
1 – Slight, 2 – Moderate, 3 – Substantial							

MN3013 PRODUCTION OF LIGHT WEIGHT COMPONENTS

	L	**T**	**P**	**C**
	3	**0**	**0**	**3**

COURSE OBJECTIVES:

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

1. To introduce to light weight composite structures and behaviour
2. To educate fundamentals of processing of light metal alloys
3. To analyse the mechanics, design and manufacturing of light metallic structures
4. To introduce to ultra-weight materials and their application
5. To familiarise the application of lightweight materials

UNIT – I LIGHTWEIGHT POLYMER COMPOSITE STRUCTURES 9

Fibre reinforced plastics (FRPs) – Overview of composite and fibre materials and mechanical properties – stiffness, stress and strain plots – failure modes – toughness mechanism – manufacturing and testing of fiber composites -anisotropic nature of the composite – sandwich – honeycomb – structures – Adaptive Composite Structures – Mechanical properties Laminar Composites – lightweight composite Fabrication methods and Processing.

UNIT – II LIGHTWEIGHT METALS AND ALLOYS 9

Introduction to Light Metals and Alloys, Strength to weight ratio- application – lightweight aluminium alloys, magnesium alloys and titanium alloys – physical metallurgy, properties and methods of manufacturing of components – Applications in Automobile, Aerospace, sports and storage

UNIT – III LIGHTWEIGHT METALLIC STRUCTURES IN ENGINEERING 9

Overview of Open and Closed Box Beams –Shear Center, Torsion - Deflection - Beam Columns- Stability of Thin-Walled Pressure Vessels – bellows -diaphragm-– fins – metallic lattice structures – hierarchical structures- order - metallic foams – Origami, folded and deployable structures – structural stiffness through folds and interlock – Overview of manufacturing of lightweight structure

UNIT – IV ULTRA LIGHTWEIGHT MATERIALS 9

Introduction to Sol-Gel Process Fundamentals – Hydrolysis and condensation reactions – Catalysts and kinetics – Influence of parameters on particle morphology and size- Aerosol and Xerogel Generation Techniques- Catalysis and energy applications – Environmental and air pollution control – Biomedical and drug delivery applications – Coatings and functional materials.

UNIT – V ENGINEERING APPLICATIONS OF LIGHT WEIGHT MATERIALS 9

Materials used in tennis rackets, golf clubs, etc. Design principles for lightweight and high-performance sports equipment, Impact of material properties on player performance, Lightweight Materials in Transportation-bicycles, automobiles, and aircraft - Materials used in prosthetic limbs and implants, Biocompatibility and bioengineering considerations, Aerospace Materials for Drone blades, space shuttle - Domestic LPG Cylinders- Economic and Environmental Impact of Materials-Life cycle assessment of materials

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Discuss on lightweight composites and their behaviour.
CO2 Select alloy and processing of lightweight metal alloys.
CO3 Analyze stress, strain, and deflection etc of light metallic structures.
CO4 Appraise the ultra-weight materials and their application.
CO5 Discuss the applications of lightweight materials in various field of engineering.

REFERENCES:
1. Ian Polmear, “Light Alloys - From Traditional Alloys to Nanocrystals”, Elsevier /Butterworth-Heinemann, Fourth Edition, 2006.
2. Kaushik Kumar, Bathini Sridhar Babu, J. Paulo Davim, “Light Weight Materials”, Wiley-ISTE, First Edition, 2022.
3. Omar Faruk, Jimi Tjong, MohiniSain, “Lightweight and Sustainable Materials for Automotive Applications”,Firstedition.CRC Press, 2017.
4. Zaini Ahmad (Ed.), “Lightweight Materials for Structural Applications”, Pener bit UTM Press, Fourth Edition, 2020.
5. Jeffrey Brinker, C. and George W. Scherer, “Sol-Gel Science: The Physics and Chemistry of Sol-Gel Processing”, Academic Press ,2014.
6. Campbell, F.C, “Lightweight Materials: Understanding the Basics”, ASM International, 2012.
7. Mallick, “Materials, Design and Manufacturing for Lightweight Vehicles”, Woodhead Publishing, 2020.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	3	1	1	2	2	1	1.7
CO2	1	1	1	2	1	1	1.2
CO3	3	1	2	2	3	1	2.0
CO4	2	1	2	2	1	1	1.5
CO5	0	1	1	1	1	1	1.0
POs Average	2.3	1.0	1.4	1.8	1.6	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MN3014 PRODUCTION OF MEDICAL PRODUCTS L T P C

3 0 0 3

COURSE OBJECTIVES:

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

1. To understand the fundamental of material interaction with host and testing
2. To present overview of manufacturing metallic implants
3. To present overview of manufacturing polymeric implants
4. To present overview of manufacturing ceramic implants
5. To introduce the steps of fabrication of medical devices and regulatory

UNIT – I CELL INTERACTION WITH MATERIALS 9

Biocompatibility – Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – host response: the inflammatory process – coagulation and hemolysis – in vitro and in vivo evaluation of biomaterials- Biological evaluation process (general biocompatibility testing considerations and test-specific considerations), Endpoints of biocompatibility testing (ISO 10993-1: 2018) as per the category of medical device- classification of biomaterials –tissue engineering- Sterilization Techniques.

UNIT – II METALLIC IMPLANTS 9

Hot isostatic pressing- forging- forming- additive manufactured- cast- implants (orthopedic and dental) – total hip replacement- micromachining- polishing- texturing- diamond like carbon – hydroxyapatite coating- bio functionalization - Ti alloys-degradable metals (Mg, Ta)- corrosion and prevention- Mechanical properties: tensile, compressive, shear, wear and fatigue testing of implants (cardiovascular, orthopedic and dental) and different implant materials (ISO 19213:2017, ISO 12106:2017, ISO 5840-1: 2015 and ISO 14801, etc.)

UNIT – III POLYMERIC IMPLANTS 9

Polymethylmethacrylate (PMMA-Polylactic acid (PLA) and polyglycolic acid (PGA) - Polycaprolactone (PCL) - UV curable resin- PTFE-PEEK- Ultra-high-molecular-weight polyethylene- Biopolymers- Collagens- Elastin- Cellulose and derivatives- Stimulus responsive materials- Orthopedics, Cardiovascular, Respiratory Patches and Tubes, eye lens- fabrication- polishing- injection molding- compression molding- additive manufacturing- Porous products - Solvent casting/particulate leaching- Gas foaming- Cryogelation- Freeze drying - electrospinning- scaffold for regeneration – wound- nerve – drug delivery system- adhesives- sutures

UNIT – IV CERAMIC IMPLANTS 9

Bio ceramics -Silicate glass - apatite/wollastonite – Alumina (Al_2O_3) – Zirconia (ZrO_2)-Carbon- Calcium phosphates (CaP) – Resorbable Ceramics – surface reactive ceramics- porous scaffold – machinable ceramics – bulk metallic glass- plasma spraying- additive manufacturing- powder/granulates for filling defects- dental- paste.

UNIT – V BIOMEDICAL DEVICES AND REGULATORY PERSPECTIVES 9

Cardiovascular Prostheses: Heart Valves and Stents – Blood Vessels – Musculoskeletal Soft Tissues: Meniscus, Intervertebral Disk –Implants for Plastic Surgery – cochlear implants; Implantable neural prostheses- Wearable devices (finger movement) – Manufacturing aspects. Single-use Devices, Clean room assembly, Packaging- Reusable devices. Medical Device regulations – US FDA, Existing regulation in India for medical devices. Basics of the Quality Management System for medical devices (ISO 13485, FDA requirements), Quality Systems Regulation.

TOTAL: 45 PERIODS

Attested

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 List the cascade of events with material interaction with host and types of testing.
CO2 Explain the manufacturing process metallic implants.
CO3 Compare the various manufacturing methods of polymeric implants.
CO4 Explain the manufacturing of ceramic implants.
CO5 Discuss the fabrication process of medical devices and regulatory.

REFERENCES:

1. Paul H. King, Richard C. Fries, Arthur T. Johnson, “Design of Biomedical Devices and Systems”,CRC Press, Third Edition, 2019.
2. Buddy D. Ratner, Allan S. Hoffman, Frederick Schoen, Jack E. Lemons, “Biomaterials Science: An Introduction to Materials in Medicine”, Elsevier Academic Press, Third Edition, 2013.
3. Larry L. Hench, “An introduction to Bioceramics”, ICP, Second Edition, 2013.
4. Peter J. Ogrodnik, “Medical Device Design: Innovation from Concept to Market”, Academic Press Inc, 1 Edition (2013).
5. StefanosZenios , Josh Makower , Paul Yock, Todd J. Brinton, Uday N. Kumar, Lyn DenendThomas M. Krummel, “Biodesign: The Process of Innovating Medical Technologies”, Cambridge University Press; First Edition ,2009.
6. Andrés D. Lantada, “Handbook on Advanced Design and Manufacturing Technologies for Biomedical Devices”. Springer London 2013
7. “Materials for Medical Devices”, ASM Handbook Volume 23, Tenth Edition ,2003

Mapping of COs with POs							
PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	1	-	1	2	1	1.2
CO2	2	1	1	1	2	1	1.3
CO3	2	1	1	1	2	1	1.3
CO4	2	1	1	1	2	1	1.3
CO5	0	1	0	1	0	1	1.0
POs Average	1.8	1.0	1.0	1.0	2.0	1.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

Attested

MN3015	**SEMICONDUCTOR MANUFACTURING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

DIRECTOR
Centre for Academic Courses
Anna University, Chennai-600 025

COURSE OBJECTIVES:

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

1. To introduce single crystal silicon manufacturing, silicon doping and compounds of silicon.
2. To impart knowledge on manufacturing process of Complementary Metal–Oxide–Semiconductor.
3. To familiarise the technology and challenges in assembly and packaging
4. To introduce tools and testing of microelectronics.
5. To introduce GaAs, bipolar transistors and micro electromechanical systems

UNIT – I INTRODUCTION TO SILICON AND ITS MANUFACTURING 9

Single crystal manufacturing-silicon ingot growth –directional solidification – Guttering-slicing – planarization- chemico mechanical polishing- Silicon -doping. Conductivity, charge densities, E-K relation, Fermi level, continuity equation, Hall Effect and its applications. diffusion – ion implantation – thermal oxidation – polysilicon coating – precursors for chemical vapour deposition of silicon components – epitaxial coating- Properties of silicon and its compounds

UNIT – II COMPLEMENTARY METAL–OXIDE– SEMICONDUCTOR 9

Photolithography – Sources: optical- UV- X-ray photoresist –mask materials – coating – pattern transfer –etching – Back-end Technology – wet – dry – metallization – physical vapour deposition –– plasma science and types of generation – RF Magnetron – electron beam – laser beam-Atomic Layer Deposition (ALD)of high-k dielectrics – Fabrication of metal oxide semiconductor field effect transistor (MOSFET) – illustration.

UNIT – III ASSEMBLY AND PACKAGING 9

Clean room, vacuum technology, short range force interaction, challenges in 2D/3D structures, bonding – silicon – silicon, silicon- silicon di-oxide, silicon – phosphate silicate glass – Device isolation – contacts- passive components – process integration - wire bonding – sealing – levels of packaging – role of fabrication in performance of electronic/electrical/ electromechanical functions.

UNIT – IV INSTRUMENTS, TOOLS, INSPECTION AND TESTING 9

Microgripper/ manipulators – stage/ platform – tools – vision system – electrical testing - Parasitic components – Future trends and Challenges: Challenges for integration, system on chip.

UNIT – V GaAs TECHNOLOGIES, SILICON BIPOLAR TECHNOLOGIES AND MICROELECTROMECHANICAL SYSTEMS 9

Metal–semiconductor field-effect transistor (MESFET) – modulation-doped field effect transistor (MODFET) – Monolithic Microwave IC (MMIC) – Bipolar Junction Transistors (BJT): basic principles and models of operation – bulk micromachining – 3D structure – DIRE – LIGA process – transducer – electro capacitive- micro accelerometer – illustration

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon successful completion of the course, students should be able to

CO1 Discuss the science of single crystal silicon, doping and properties of silicon and its compounds.

CO2 Explain the manufacturing process involved in fabrication of Complementary Metal Oxide–Semiconductor.

CO3 List the technology and challenges in assembly and packaging

CO4 Discuss an overview of tools and testing of microelectronics.

CO5 Explain the fundamentals of GaAs, bipolar transistors and micro electromechanical systems: device and its fabrication.

REFERENCES:

1. Hong Xiao, "Introduction to Semiconductor Manufacturing Technology", Second Edition, , SPIE Press, 2013.
2. UzodinmaOkoroanyanwu, "Chemistry and Lithography", SPIE/Wiley, First Edition, 2011.
3. Stephen A. Campbell, "The Science and Engineering of Microelectronic Fabrication", Second Edition, Oxford University Press, 2001.
4. May, G. S. and Sze, S. M., "Fundamentals of Semiconductor Fabrication", First Edition, Wiley India, 2007.
5. Mark Madou, "Fundamentals of Microfabrication'', Second Edition, CRC Press, New York, 2017.
6. Plummer, J.D., Deal, M. D. and Griffin, P. B, "Silicon VLSI Technology, Fundamentals Practice and Modeling", Pearson education, First Edition, 2002.

Mapping of COs with POs

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	COs Average
CO1	1	1	1	1	0	2	1.2
CO2	2	1	1	2	1	2	1.5
CO3	2	1	1	2	0	2	1.6
CO4	1	1	1	1	0	2	1.2
CO5	1	1	1	1	0	2	1.2
POs Average	1.4	1.0	1.0	1.4	1.0	2.0	
1 – Slight, 2 – Moderate, 3 - Substantial							

MR3053 **DRONE TECHNOLOGIES**

	L	T	P	C
	3	0	0	3

COURSE OBJECTIVES:

1. To understand the concept, vocabulary, and history of drone technology, and its impact on businesses.
2. To learn the design, fabrication, and programming of drones, including the classification of UAVs, assembling drone parts, and programming methods.
3. To gain practical skills in drone flying and operation, including flight modes, drone controls, sensor usage, and mobile device integration.
4. To explore the commercial applications of drones in various industries such as insurance, logistics, agriculture, inspection, and filmmaking.
5. To discuss the future trends in drone technology, safety risks, aviation regulations, miniaturization, autonomy, and the use of drones in swarms.

UNIT I INTRODUCTION TO DRONE TECHNOLOGY 9

Drone Concept - Vocabulary Terminology- History of drone - Types of current generation of drones based on their method of propulsion- Drone technology impact on the businesses - Drone business through entrepreneurship- Opportunities/applications for entrepreneurship and employability

UNIT II DRONE DESIGN, FABRICATION AND PROGRAMMING 9

Classifications of the UAV -Overview of the main drone parts- Technical characteristics of the parts -Function of the component parts -Assembling a drone- The energy sources- Level of autonomy- Drones configurations -The methods of programming drone- Download program -Install program on computer- Running Programs- Multi rotor stabilization- Flight modes -Wi-Fi connection

UNIT III DRONE FLYING AND OPERATION 9

Concept of operation for drone -Flight modes- Operate a small drone in a controlled environment- Drone controls F-light operations –management tool –Sensors- Onboard storage capacity -Removable storage devices- Linked mobile devices and applications

UNIT IV DRONE COMMERCIAL APPLICATIONS 9

Choosing a drone based on the application -Drones in the insurance sector- Drones in deliveri mail, parcels and other cargo- Drones in agriculture- Drones in inspection of transmission lin and power distribution -Drones in filming and panoramic picturing

UNIT V FUTURE DRONES AND SAFETY 9

The safety risks- Guidelines to fly safely -Specific aviation regulation and standardization- Drone license- Miniaturization of drones- Increasing autonomy of drones -The use of drones in swarms

TOTAL 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

CO1 Recall and explain the concepts, vocabulary, and historical development of drone technology.

CO2 Analyze and evaluate the design, fabrication, and programming aspects of drones, demonstrating technical knowledge of drone components and their functions.

CO3 Demonstrate practical skills in flying and operating drones, including understanding flight modes, controlling drones, utilizing sensors, and integrating mobile devices.

CO4 Apply knowledge of drone technology to identify and discuss the commercial applications of drones in various industries, evaluating their benefits and limitations.

CO5 Evaluate and discuss the future trends and safety considerations in drone technology, demonstrating an understanding of aviation regulations, miniaturization, autonomy, and swarm usage.

REFERENCES

1. Daniel Tal and John Altschuld, “Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation and Implementation”, John Wiley & Sons, Inc, 2021.
2. Terry Kilby and Belinda Kilby, “Make: Getting Started with Drones “, Maker Media, Inc,2016.
3. John Baichtal, “Building Your Own Drones: A Beginners' Guide to Drones, UAVs, and ROVs”, Que Publishing, 2016
4. Zavrsnik, “Drones and Unmanned Aerial Systems: Legal and Social Implications for Security and Surveillance”, Springer, 2018.

COs	POs					
	1	2	3	4	5	6
1	1	1	1	3	-	1
2	1	1	3	2	-	1
3	1	1	2	2	-	1
4	1	1	3	2	-	2
5	1	1	1	2	-	2
Avg	**1**	**1**	**2**	**2.2**	**-**	**1.4**