KAMARAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

(An Autonomous Institution - AFFILIATED TO ANNA UNIVERSITY, CHENNAI)

S.P.G.Chidambara Nadar - C.Nagammal Campus

S.P.G.C.Nagar, K.Vellakulam - 625 701 (Near Virudhunagar), Madurai District.

DEPARTMENT OF MECHANICAL ENGINEERING

M.E. MANUFACTURING ENGINEERING

REGULATIONS - 2020 (AUTONOMOUS)

CHOICE BASED CREDIT SYSTEM

VISION OF THE DEPARTMENT:

To make the Department of Mechanical Engineering unique of its kind in the field of Research and Development activities in the prominent fields of Mechanical Engineering in this part of the world.

MISSION OF THE DEPARTMENT:

To impart highly Innovative and Technical knowledge in the field of Mechanical Engineering to the urban and unreachable rural students' folks, through "TOTAL QUALITY EDUCATION".

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To provide graduates with a solid foundation in mathematical, scientific and engineering fundamentals required to solve Manufacturing engineering problems

II. To train graduates with good scientific and engineering knowledge so as to comprehend, analyze, design, and create novel products and solutions for the real-life problems.

III. To provide graduates with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.

PROGRAMME OUTCOMES

Engineering Graduates will be able to:

PO1 **ENGINEERING KNOWLEDGE**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 **PROBLEM ANALYSIS**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 **DESIGN/DEVELOPMENT OF SOLUTIONS**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 **CONDUCT INVESTIGATIONS OF COMPLEX PROBLEMS**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 **MODERN TOOL USAGE**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6 **THE ENGINEER AND SOCIETY**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 **ENVIRONMENT AND SUSTAINABILITY**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 **ETHICS**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 INDIVIDUAL AND TEAM WORK: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 COMMUNICATION: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 PROJECT MANAGEMENT AND FINANCE: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 LIFE-LONG LEARNING: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOME

By completion of Post Graduate Manufacturing Engineering, the graduates will have following Program specific outcomes.

PSO 1. Students will be able to create solution by solving, analyzing and designing problems related to manufacturing systems and practices.

PSO 2. Students will be able to design and develop optimal solution to the needs of Industry and society.

PEO/PO MAPPING

PEO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
II	✓	✓	✓	✓	✓	✓	✓	✓			✓	
III	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

M.E. MANUFACTURING ENGINEERING (FULL TIME)

REGULATIONS 2020 (R2020)

CURRICULUM AND SYLLABUS

SEMSTER 1								
S. No	**Subject Code**	**Course Title**	**Category**	**CP**	**CREDITS**			
					L	**T**	**P**	**C**
1.	MA1104	APPLIED MATHEMATICS IN MANUFACTURING	FC	5	3	1	0	4
2.	MF1101	ADVANCES IN CASTING AND WELDING	PC	3	3	0	0	3
3.	MF1102	ADVANCES IN MANUFACTURING TECHNOLOGY	PC	3	3	0	0	3
4.	MF1103	THEORY OF METAL CUTTING	PC	3	3	0	0	3
5.	MF1104	THEORY OF METAL FORMING	PC	3	3	0	0	3
6	PE 1	PROFESSIONAL ELECTIVE -1	PE	3	3	0	0	3
	PRACTICAL							
7	MF1111	METAL FORMING AND AUTOMATION LAB	PC	4	0	0	4	2
8	MF1112	MODELLING AND SIMULATION LABORATORY	PC	4	0	0	4	2
			TOTAL	**25**	**18**	**1**	**7**	**23**

SEMSTER 2								
S. No	**Subject Code**	**Course Title**	**Category**	**CP**	**CREDITS**			
					L	**T**	**P**	**C**
9	MF1201	OPTIMIZATION TECHNIQUES IN MANUFACTURING	PC	5	3	1	0	4
11	MF1202	TOOLING FOR MANUFACTURING	PC	3	3	0	0	3
12	MF1203	CNC AND METROLOGY	PC	3	3	0	0	3
13	PE 2	PROFESSIONAL ELECTIVE 2	PE	3	3	0	0	3
14	PE 3	PROFESSIONAL ELECTIVE 3	PE	3	3	0	0	3
15		ONLINE COURSE	OL	-	-	-	-	3
	PRACTICAL							
16	MF1211	CNC & METROLOGY LAB	PC	3	0	0	3	2
17	MF1221	TECHNICAL SEMINAR	EEC	2	0	0	2	1
			TOTAL	**22**	**15**	**1**	**5**	**22**

SEMSTER 3								
S. No	**Subject Code**	**Course Title**	**Category**	**CP**	**CREDITS**			
					L	**T**	**P**	**C**
18	OE	OPEN ELECTIVE	OE	3	3	0	0	3
19	PE 4	PROFESSIONAL ELECTIVE 4	PE	3	3	0	0	3
20	PE 5	PROFESSIONAL ELECTIVE 5	PE	3	3	0	0	3
	PRACTICAL							
21	MF1321	PROJECT WORK –PHASE I	EEC	12	0	0	12	6
			TOTAL	**21**	**9**	**0**	**12**	**15**
SEMSTER 4								
S. No	**Subject Code**	**Course Title**	**Category**	**CP**	**CREDITS**			
					L	**T**	**P**	**C**
22	MF1421	PROJECT WORK –PHASE II	EEC	24	0	0	24	12
			TOTAL	**24**	**0**	**0**	**24**	**12**

Semester wise Credits	**I**	**II**	**III**	**IV**	**Total Credits**
	23	**22**	**15**	**12**	**72**

TOTAL CREDITS TO BE EARNED FOR THE AWARD OF THE DEGREE = 72

PROGRAM CORE COURSES (PC)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1101	ADVANCES IN CASTING AND WELDING	PC	3	3	0	0	3
2.	MF1102	ADVANCES IN MANUFACTURING TECHNOLOGY	PC	3	3	0	0	3
3.	MF1103	THEORY OF METAL CUTTING	PC	3	3	0	0	3
4.	MF1104	THEORY OF METAL FORMING	PC	3	3	0	0	3
5.	MF1111	METAL FORMING AND AUTOMATION LAB	PC	3	0	0	3	2
6.	MF1112	MODELLING AND SIMULATION LABORATORY	PC	4	0	0	4	2
7.	MF1201	OPTIMIZATION TECHNIQUES IN MANUFACTURING	PC	5	3	1	0	4
8.	MF1202	TOOLING FOR MANUFACTURING	PC	3	3	0	0	3
9.	MF1203	CNC AND METROLOGY	PC	3	3	0	0	3
10.	MF1211	CNC AND METROLOGY LAB	PC	3	0	0	3	2

FOUNDATION COURSE (FC)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MA1104	APPLIED MATHEMATICS IN MANUFACTURING	FC	5	3	1	0	4

PROFESSIONAL ELECTIVE COURSES (PE)

SEMESTER 1, PROFESSIONAL ELECTIVE 1 (PE 1)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1131	DESIGN FOR MANUFACTURE, ASSEMBLY AND ENVIRONMENT	PE	3	3	0	0	3
2.	MF1132	LEAN MANUFACTURING SYSTEMS AND IMPLEMENTATION	PE	3	3	0	0	3
3.	MF1133	MANUFACTURING MANAGEMENT	PE	3	3	0	0	3
4.	MF1134	COMPUTER INTEGRATED MANUFACTURING SYSTEMS	PE	3	3	0	0	3

SEMESTER 2, PROFESSIONAL ELECTIVE 2 (PE 2)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1231	RAPID MANUFACTURING	PE	3	3	0	0	3
2.	MF1232	MICRO MANUFACTURING	PE	3	3	0	0	3
3.	MF1233	GREEN MANUFACTURING	PE	3	3	0	0	3
4.	MF1234	SUSTAINABLE MANUFACTURING	PE	3	3	0	0	3

SEMESTER 2, PROFESSIONAL ELECTIVE 3 (PE 3)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1235	FLUID POWER AUTOMATION	PE	3	3	0	0	3
2.	MF1236	COMPUTER AIDED PRODUCT DESIGN	PE	3	3	0	0	3
4.	MF1237	ROBOT DESIGN AND PROGRAMMING	PE	3	3	0	0	3
5.	MF1238	INDUSTRIAL DESIGN AND ERGONOMICS	PE	3	3	0	0	3

SEMESTER 3, PROFESSIONAL ELECTIVE 4 (PE 4)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1331	MATERIALS TECHNOLOGY	PE	3	3	0	0	3
2.	MF1332	POLYMERS AND COMPOSITE MATERIALS	PE	3	3	0	0	3
3.	MF1333	MATERIALS MANAGEMENT	PE	3	3	0	0	3
4.	MF1334	MATERIAL TESTING AND CHARACTERIZATION	PE	3	3	0	0	3

SEMESTER 3, PROFESSIONAL ELECTIVE 5 (PE 5)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1335	MANUFACTURING SYSTEM SIMULATION	PE	3	3	0	0	3
2.	MF1336	FINITE ELEMENT ANALYSIS IN MANUFACTURING	PE	3	3	0	0	3
3.	MF1337	RESEARCH METHODOLOGY AND IPR	PE	3	3	0	0	3
5.	MF1338	NON-DESTRUCTIVE TESTING AND EVALUATION	PE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
1.	MF1221	TECHNICAL SEMINAR	EEC	2	0	0	2	1
2.	MF1321	PROJECT WORK –PHASE I	EEC	12	0	0	12	6
3.	MF1421	PROJECT WORK –PHASE II	EEC	24	0	0	24	12

OPEN ELECTIVE COURSES (OE)

S. No	Subject Code	Course Title	Category	CP	CREDITS			
					L	T	P	C
5.	OMF151	3D PRINTING & DESIGN (AICTE Recommended Course in Emerging Area)	OE	3	3	0	0	3
6.	OMF152	COMPOSITE MATERIALS	OE	3	3	0	0	3
7.	OMF153	OPERATIONS RESEARCH	OE	3	3	0	0	3

SUMMARY

S.NO	Subject Area	CREDITS PER SEMESTER				Credits Total	Percentage
		I	II	III	IV		
1	FC	4	-	-	-	4	5.56
2	PC	16	12	-	-	28	38.89
3	PE	3	6	6	-	15	20.83
4	OE	-	-	3	-	3	4.17
5	OL	-	3	-	-	3	4.17
6	EEC	-	1	6	12	19	26.39
TOTAL		23	22	15	12	72	100

FC - FOUNDATION COURSE

PC - PROGRAM CORE COURSES

PE - PROFESSIONAL ELECTIVE COURSES

OE - OPEN ELECTIVE COURSE

OL - ONLNE COURSE

EEC - EMPLOYABILITY ENHANCEMENT COURSES

MA1104	APPLIED MATHEMATICS IN MANUFACTURING	L	T	P	C
		4	0	0	4

OBJECTIVES:

- To provide the solid foundation on topics in random variables and various statistical methods.
- To address the issues of correlation, regression, estimation theory, testing of hypothesis and Design of experiments in various Manufacturing Variables.

UNIT I RANDOM VARIABLES AND DISTRIBUTIONS 12

Random Variable – Discrete random variable – Continuous random variable – Properties – Moments and Moment Generating Function – Binomial – Poisson– Geometric– Uniform– Exponential– Normal – Bivariate distribution – Conditional and Marginal distribution.

UNIT II METHODS OF CORRELATION AND ESTIMATION THEORY 12

Correlation coefficient – Properties – Problems – Rank correlation – Regressions lines – Problems- Unbiased estimators – Method of moments – Maximum likelihood estimation.

UNIT III TESTING OF HYPOTHESIS 12

Sampling distributions – Type I and Type II errors – Small and large samples – Tests based on Normal, t, Chi square and F distributions for testing of mean, variance and proportions – Tests for independence of attributes and goodness of fit.

UNIT IV DESIGN OF EXPERIMENTS 12

Planning of experiments – Randomization, replication and Blocking – ANOVA – Completely randomized design, Randomized block design – Latin Square Design – Hands on training: using minitab software.

UNIT V FACTORIAL EXPERIMENTS 12

Main and interaction effects –Two and three Factor full factorial Designs, 2k designs with Two and Three factors- Yate's Algorithm. Hands on training: using minitab software.

TOTAL: 60 PERIODS

OUTCOMES

CO 1 : At the end of the course, students will be able to
CO 2 : Analyze the performance in terms of random variables and distributions achieved by the determined solution.
CO 3 : Estimate the consistency, efficiency and un biasedness of estimators, method of maximum likelihood estimation and Curve fitting.

CO 4 : Apply statistical tests in testing hypothesis on various data.
CO 5 : Solve basic design of experimental problems in Manufacturing.
CO 6 : Apply full factorial design using design of experiments in real life problems

REFERENCES:

1. Devore, J. L., 2014, Probability *and Statistics for Engineering and the Sciences*, 8th Edition, Cengage Learning.
2. Gupta, S.C and Kapoor, V.K., 2001, *Fundamentals of Mathematical Statistics*, Sultan and Sons, New Delhi.
3. John, E. Freunds, 2011, *Mathematical statistics with applications*, Pearson Education India.
4. Montgomery, D.C., 2002, Design *and Analysis of Experiments*, John Wiley and Sons, 5th Edition.
5. Libschutz, S., 2010, *Probability and Statistics*, 4th Edition, McGraw Hill, New Delhi.
6. Veerarajan,T., 2008, *Probability, Statistics and Random Processes,* 3rd Edition., Tata Mc Graw-Hill.

MF1101	ADVANCES IN CASTING AND WELDING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the metallurgical concepts and applications of casting and welding process.
- To acquire knowledge in CAD of casting and automation of welding process.

UNIT I CASTING DESIGN 8

Heat transfer between metal and mould — Design considerations in casting – Designing for directional solidification and minimum stresses - principles and design of gating and risering

UNIT II CASTING METALLURGY 8

Solidification of pure metal and alloys – shrinkage in cast metals – progressive and directional solidification — Degasification of the melt-casting defects – Castability of steel , Cast Iron, Al alloys, Babbit alloy and Cu alloy.

UNIT III RECENT TRENDS IN CASTING AND FOUNDRY LAYOUT 8

Shell moulding, precision investment casting, CO2 moulding, centrifugal casting, Die casting, Continuous casting, Counter gravity low pressure casting, Squeeze casting

and semisolid processes. Layout of mechanized foundry – sand reclamation – material handling in foundry pollution control in foundry —– Computer aided design of casting.

UNIT IV WELDING METALLURGY AND DESIGN 10

Heat affected Zone and its characteristics – W eldability of steels, cast iron, stainless steel, aluminum, Mg , Cu , Zirconium and titanium alloys – Carbon Equivalent of Plain and alloy steels Hydrogen embrittlement – Lamellar tearing – Residual stress – Distortion and its control . Heat transfer and solidification - Analysis of stresses in welded structures – pre and post welding heat treatments – weld joint design – welding defects – Testing of weldment.

UNIT V RECENT TRENDS IN WELDING 11

Friction welding, friction stir welding – explosive welding – diffusion bonding – high frequency induction welding – ultrasonic welding – electron beam welding – Laser beam welding –Plasma welding – Electroslag welding- narrow gap, hybrid twin wire active TIG – Tandem MIG- modern brazing and soldering techniques – induction, dip resistance, diffusion processes – Hot gas, wave and vapour phase soldering. Overview of automation of welding in aerospace, nuclear, surface transport vehicles and under water.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Understand and apply the principles of design in metal casting processes

CO 2 : Demonstrate the metallurgical behaviour and defects in casting processes

CO 3 : Understand the principles of different types of casting processes

CO 4 : Explain the metallurgical changes in weldments and its properties on various materials and alloys

CO 5 : Describe the different types of welding processes.

REFERENCES:

1. ASM Handbook Vol.6, 2003, *Welding Brazing & Soldering*.
2. ASM Handbook, Vol 15, 2004, *Casting*.
3. Carrry B., 2002, *Modern Welding Technology*, Prentice Hall Pvt Ltd.
4. Cornu.J., 1994, *Advanced welding systems – Volumes I, II and III*, JAICO Publishers.
5. Heineloper & Rosenthal, 2000, *Principles of Metal Casting*, Tata McGraw Hill.
6. Iotrowski, 1987, Robotic *welding – A guide to selection and application*, Society of mechanical Engineers.
7. Jain P.L., 2003*, Principles of Foundry Technology*, Tata McGraw Hill Publishers.

8. Lancaster.J.F., 1980, *Metallurgy of welding,* George Alien & Unwin Publishers.
9. Parmer R.S., 2002, *Welding Engineering and Technology*, Khanna Publishers.
10. Schwariz, M.M., 1981, *Source book on innovative welding processes*, American Society for Metals (OHIO).
11. Srinivasan N.K.,2002, *Welding Technology*, Khanna Tech Publishers.

MF1102	ADVANCES IN MANUFACTURING TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To create awareness on Abrasive aided machining
- To understand electrical and electrochemical machining processes.
- To analyze the principles of high energy aided machining.
- To study the surface and bulk machining processes of silicon wafer.
- To introduce students to the major manufacture steps in electronic circuit boards.

UNIT I ABRASIVE AIDED MACHINING PROCESSES 9

Abrasive machining – water jet machining - ultrasonic machining –Abrasive flow machining Magnetorheological Abrasive flow machining- construction working principle – steps - types – process parameters – derivations – problems, merits, demerits and applications.

UNIT II ELECTRICAL AND CHEMICAL AIDED MACHINING PROCESSES 9

Wire cut EDM - Electric discharge machining – Electrochemical machining – chemical machining – Maskants - Electrochemical grinding - construction – principle – types – control - circuits – tool design – merits, demerits and applications. Hybrid Machining.

UNIT III HIGH ENERGY AIDED MACHINING PROCESSES 9

Laser beam machining – Electron beam machining – Plasma arc machining – Ion beam machining – construction working principle types – process parameter – derivations – problems, merits, demerits and applications.

UNIT IV FABRICATION OF MICRO DEVICES 9

Semiconductors – Si wafer - planarization – Oxidation - diffusion – ion implantation – etching – metallization – bonding – surface and bulk machining – LIGA Process.

UNIT V MICROFABRICATION TECHNOLOGY 9

Moulding – PCB board hybrid and MCM technology – programmable devices and ASIC –
electronic material and processing– stereolithography – Solid free form fabrication - SAW devices, Surface Mount Technology

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Understand and grasp the significance of modern machining process and its applications.
- **CO 2 :** Identify the selection of machining process and its parameters.
- **CO 3 :** Express and appreciate the cutting-edge technologies and apply the same for research purposes.
- **CO 4 :** Measure the stages involved in fabrication of micro devices.
- **CO 5 :** Create new devices involved in micro fabrication and recent technology

REFERENCES:

1. Brahem T. Smith, 2016, *Advanced Machining,* I.F.S., UK.
2. Jaeger R.C.,1998, *Introduction to Microelectronic Fabrication,* Addison Wesley, 2ndEdition.
3. Jain V K, 2012, *Micromanufacturing Processes*, CRC Press.
4. Julian W. Gardner, Vijay K Varadan and Osama O Awadelkarim, 2013, *Microsensors MEMS and Smart devices*, John Willey.
5. Pandey P.C. & Shan HS, 1980, *Modern Machining Processes*, Standard Publishing Co., 1stEdition.
6. Serope Kalpakjian & Steven R. Schmid, 2018, *Manufacturing Process for Engineering Material*, Pearson Education, 6th Edition.

MF1103	**THEORY OF METAL CUTTING**	**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

OBJECTIVES:

- To make the students familiar with the various principles of metal cutting, cutting tool materials
- To make the students familiar with wear mechanisms during the machining operation.

UNIT I INTRODUCTION **9**

Need for rational approach to the problem of cutting materials-observation made in the cutting of metals-basic mechanism of chip formation-thin and thick zone modes-types

of chips-chip breaker- orthogonal Vs oblique cutting-force velocity relationship for shear plane angle in orthogonal cutting energy consideration in machining-review of Merchant, Lee and Shafter theories-critical comparison.

UNIT II SYSTEM OF TOOL NOMENCLATURE 9

Nomenclature of single point cutting tool-System of tool nomenclature and conversion of rake angles nomenclature of multi point tools like drills, milling-conventional Vs climb milling, mean cross sectional area of chip in milling-specific cutting pressure.

UNIT III THERMAL ASPECTS OF MACHINING 9

Heat distribution in machining-effects of various parameters on temperature-methods of temperature measurement in machining-hot machining-cutting fluids.

UNIT IV TOOL MATERIALS, TOOL LIFE AND TOOL WEAR 9

Essential requirements of tool materials-development in tool materials-ISO specification for inserts and tool holders-tool life-conventional and accelerated tool life tests-concept of mach inability index- economics of machining.

UNIT V WEAR MECHANISMS AND CHATTER IN MACHINING 9

Processing and Machining – Measuring Techniques – Reasons for failure of cutting tools and forms of wear-mechanisms of wear-chatter in machining-factors effecting chatter in machining-types of chatter mechanism of chatter.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Evaluate the tool wear and tool life for various type of cutting tools (single point, multi – point etc.)

CO 2 : Calculate various mechanics (cutting force relationships) during metal cutting operations.

CO 3 : Determine the tool temperature and heat generation during cutting operation using various measurement techniques and also select optimal cutting fluid based on the application.

CO 4 : Select the machining parameters for various machining operations.

CO 5 : Get knowledge of various recent cutting tool materials and its properties to aid them in the selection of efficient tool material for the machining process.

REFERENCES:

1. Bhattacharya.A., 1984, *Metal Cutting Theory and practice*, Central Book Publishers, India.

2. Boothroid D.G. & Knight W.A., 1989, *Fundamentals of machining and machine tools*, Marcel Dekker, Newyork.
3. Shaw.M.C., 1984, *Metal cutting principles*, Oxford Clare Don Press.

MF1104	THEORY OF METAL FORMING	L	T	P	C
		4	0	0	4

OBJECTIVES:

- To provide knowledge on the mechanism involved in plastic deformation and parameter representation.
- Enable students to understand various bulk forming process and its recent technology.
- To provide overview of various sheet metal forming process
- To study the powder metallurgy techniques and Special metal forming processes.
- To introduce the significance of surface treatment and industrial application of metal forming.

UNIT I THEORY OF PLASTICITY 9

Theory of plastic deformation – Yield criteria – Tresca and Von-mises – Distortion energy – Stress strain relation – Mohr's circle representation of a state of stress – cylindrical and spherical co-ordinate system – upper and lower bound solution methods – Overview of FEM applications in Metal Forming analysis.

UNIT II THEORY AND PRACTICE OF BULK FORMING PROCESSES 9

Analysis of plastic deformation in Forging, Rolling, Extrusion, rod/wire drawing and tube drawing – Effect of friction – calculation of forces, work done – Process parameters, equipment used – Defects – applications – Recent advances in Forging, Rolling, Extrusion and Drawing processes – Design consideration in forming.

UNIT III SHEET METAL FORMING 9

Formability studies – Conventional processes – H E R F techniques – Superplastic forming techniques – Hydro forming – Stretch forming – Water hammer forming – Principles and process parameters – Advantage, Limitations and application.

UNIT IV POWDER METALLURGY AND SPECIAL FORMING PROCESSES 9

Overview of P/M technique – Advantages – applications – Powder preform forging – powder rolling – Tooling, process parameters and applications. - Orbital forging – Isothermal forging – Hot and cold isostatic pressing – High speed extrusion – Rubber pad forming – Fine blanking – LASER beam forming.

UNIT V **SURFACE TREATMENT AND METAL FORMING APPLICATIONS** **9**

Experiment techniques of evaluation of friction in metal forming selection – influence of temperature and gliding velocity – Friction heat generation – Friction between metallic layers – Lubrication carrier layer – Surface treatment for drawing, sheet metal forming, Extrusion, hot and cold forging. Processing of thin Al tapes – Cladding of Al alloys – Duplex and triplex steel rolling – Thermo mechanical regimes of Ti and Al alloys during deformation – Formability of welded blank sheet – Laser structured steel sheet - Formability of laminated sheet.

TOTAL: 45 PERIODS

OUTCOMES

Students will able to

CO 1 : Understand the state of stress in metal forming process.
CO 2 : To identify the appropriate bulk forming process based on the application.
CO 3 : Understand the conventional sheet metal forming process and various high energy rate forming techniques.
CO 4 : Understand the powder metallurgy forming technique.
CO 5 : Select appropriate surface heat treatment technique.

REFERENCES:

1. Altan T., 2003, *Metal forming – Fundamentals and applications*, American Society of Metals, Metals park.
2. Altan.T, Soo-Ik-oh, Gegel, HL, 1995, *Metal forming, fundamentals and Applications*, American Society of Metals, Metals Park, Ohio.
3. ASM Hand book, 2003, *Forming and Forging*, Ninth edition, Vol – 14.
4. Dieter G.E., 1988, *Mechanical Metallurgy (Revised Edition II),* McGraw Hill Co.
5. Helmi A Youssef, Hassan A. El-Hofy, 2012, *Manufacturing Technology: Materials, Processes and Equipment*, CRC publication press.
6. Marciniak,Z., Duncan J.L., Hu S.J., 2006, *Mechanics of Sheet Metal Forming*, Butterworth-Heinemann An Imprint of Elesevier.
7. Nagpal G.R., 2005, *Metal Forming Processes*, Khanna publishers.
8. Shiro Kobayashi, Soo-Ik-Oh-Altan, T, 2001, *Metal forming and Finite Element Method*, Oxford University Press.
9. Surender kumar, 2010, *Technology of Metal Forming Processes*, Prentice Hall India Publishers.

MF1111	METAL FORMING AND AUTOMATION LAB	L	T	P	C
		0	0	3	2

OBJECTIVES:

- To train the students to have a hands on having the basic concepts of metal forming processes and to determine some metal forming parameters for a given shape.

METAL FORMING **16**

1. Determination of strain hardening exponent
2. Determination of strain rate sensitivity index
3. Construction of formability limit diagram
4. Determination of efficiency in water hammer forming
5. Determination of interface friction factor
6. Determination of extrusion load
7. Study on two high rolling process

AUTOMATION **16**

1. Simulation of single and double acting cylinder circuits
2. Simulation of Hydraulic circuits
3. Simulation of electro pneumatic circuits
4. Simulation of electro hydraulic circuits
5. Simulation of PLC circuits
6. Software simulation of fluid power circuits using Automation studio.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Determine strain hardening exponent and strain rate sensitivity index for the given test materials

CO 2 : Conduct formability test and construct the limit diagram

CO 3 : Determine interface friction factor and extrusion load for the given test specimens.

CO 4 : Design and simulate basic hydraulic and pneumatic circuits

CO 5 : Design and simulate electro hydraulic and electro pneumatic circuits.

MF1112	MODELLING AND SIMULATION LABORATORY	L	T	P	C
		0	0	4	2

OBJECTIVES:

- To study the fundamentals of finite element analysis from classical method to nodal approximation method in various fields of manufacturing applications.
- To make the students to design an element by Finite element analysis.
- To develop the knowledge related to modelling and simulation in field of manufacturing.

LIST OF EXERCISES **16**

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 Cotter Joint.
8. 3D Modelling and Assemble of Couplings.
9. 3D Modelling and Assemble of Plummer Block.
10. 3D Modelling of sheet metal components.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Apply the principles of Finite Element Analysis to solve problems in the field of production engineering.
CO 2 : Design and analyze various problems in field of manufacturing
CO 3 : Identify the problems and simulate using Finite element analysis
CO 4 : Relate to Finite element analysis in various manufacturing applications.
CO 5 : Develop skills in field of design and simulation using FEA.

LIST OF EQUIPMENTS

S.NO	EQUIPMENT	QUANTITY
1.	Computer Server	1
2.	Computer nodes or systems (High end CPU with atleast 2 GB main memory) networked to the server	30
3.	Laser Printer	1
4.	CNC Lathe	1
5.	CNC milling machine	1
SOFTWARE		

6.	Any High-end integrated modeling and manufacturing CAD / CAM software	15 licenses
6.	CAM Software for machining centre and turning centre (CNC Programming and tool path simulation for FANUC / Sinumeric and Heidenhain controller)	15 licenses
8.	Licensed operating system	adequate
9.	Support for CAPP	adequate

MF1201 OPTIMIZATION TECHNIQUES IN MANUFACTURING

L	T	P	C
3	1	0	4

OBJECTIVES:

- To make use of the above techniques while modeling and solving the engineering problems of different fields.

UNIT I INTRODUCTION 8

Optimization – Historical Development – Engineering applications of optimization – Statement of an Optimization problem – classification of optimization problems.

UNIT II CLASSIC OPTIMIZATION TECHNIQUES 15

Linear programming - Graphical method – simplex method – dual simplex method – revised simplex method – duality in LP – Parametric Linear programming.

UNIT III NON-LINEAR PROGRAMMING 12

Introduction – Lagrangeon Method – Kuhn-Tucker conditions – Quadratic programming – Separable programming.

UNIT IV INTEGER PROGRAMMING AND NETWORK TECHNIQUES 15

Integer programming - Cutting plane algorithm, Branch and bound technique, Zero-one implicit enumeration – Network Techniques – Shortest Path Model – Minimum Spanning Tree Problem – Maximal flow problem.

UNIT V ADVANCES IN SIMULATION 10

Genetic algorithms – Simulated annealing – Neural Network and Fuzzy systems

TOTAL: 60 PERIODS

OUTCOMES

At the end of this course the students will be expected

CO 1 : Understand the classification and application of Optimization problems.

CO 2 : Apply the formulation of classic optimization techniques in problems.
CO 3 : Solve the nonlinear programming in optimization techniques in problems.
CO 4 : Solve the algorithms using integer& dynamic programming and also in network techniques.
CO 5 : Analyze the knowledge of optimization using advanced algorithms and simulations.

REFERENCES:

1. Hamdy A. Taha, 1997, *Operations Research – An Introduction*, Prentice Hall of India.
2. J.K.Sharma, 1997, *Operations Research – Theory and Applications,* Macmillan India Ltd.
3. P.K. Guptha & Man-Mohan, 1994, *Problems in Operations Research*, Sultan Chand & Sons.
4. R. Panneerselvam, 2005, *Operations Research*, Prentice Hall of India Private Limited, New Delhi.
5. Ravindran, Philips and Solberg, 1992, *Operations Research Principles and Practice*, John Wiley & Sons, Singapore.

MF1202	TOOLING FOR MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To study the various design considerations for tooling.
- Develop knowledge in tooling and work holding devices.

UNIT I INTRODUCTION 9

Manufacturing Processes-objectives of manufacturing processes-classification of manufacturing process-Objectives of Tool design-tool design process-Nature and scope of Tool engineering principles of economy for tooling-problems of economy in tooling-planning and tooling for economy Manufacturing principles applicable to process and tool planning-tool control-tool maintenance-tool materials and its selection.

UNIT II TOOLING FOR METAL REMOVAL PROCESSES 9

Traditional machining processes -work and tool holding devices-tool nomenclatures-Mechanism of machining-force temperature and tool life of single point tool-multipoint tools -tool design-tool wear special processes-capstan and turret lathe-tooling layout of automats-tooling in NC and CNC machines-tooling for machining centres-CAD in tool design-Jigs and fixtures-design-Non-traditional material removal processes-

mechanical, electrical thermal and chemical energy processes-principles operation-equipment-tooling parameters and limitations.

UNIT III TOOLING FOR METAL FORMING PROCESSES 9

Classification of Forming Processes-Types of presses-design of -blanking and piercing dies-simple, compound, combination and progressive dies-Drawing Dies-Bending dies-forging dies-plastic moulding dies.

UNIT IV TOOLING FOR METAL CASTING AND METAL JOINING PROCESSES 9

Tools and Equipment for moulding-patterns –pattern allowances – pattern construction-die casting tools- mechanization of foundries. Tooling for Physical joining processes Design of welding fixtures – Arc welding, Gas welding, Resistance welding, laser welding fixtures-Tooling for Soldering and Brazing Tooling for Mechanical joining processes.

UNIT V TOOLING FOR INSPECTION AND GAUGING 9

Survey of linear and angular measurements-standards of measurement-design and manufacturing of gauges- measurement of form-Inspection bench centre-co-ordinate measuring machine-tooling in CMM.

TOTAL: 45 PERIODS

OUTCOMES

At the end of this course the students are expected to

- **CO 1 :** Describe the principles in manufacturing applicable to process and tool planning
- **CO 2 :** Analyze the tool life of single point and multipoint tools
- **CO 3 :** Explain the different types of tooling dies for drawing, bending and forming processes
- **CO 4 :** Demonstrate the tools and equipment's in casting and welding process
- **CO 5 :** Illustrate the different standards for tooling measurement.

REFERENCES:

1. Cyril Donaldson, 1976, *Tool Design*, Tata McGraw Hill.
2. Hoffman E.G, 1984, *Fundamentals of tool design,* SME.
3. Kalpak Jian S., 1995, *Manufacturing Engineering and Technology*, Addison Wesley.
4. L E Doyle, 1950, *Tool Engineering,* Prentice Hall.
5. Wellar, J, 1984*, Non-Traditional Machining Processes*, SME.

MF1203	CNC MACHINE AND METROLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Understand evolution and principle of CNC machine tools.
- Write simple programs for CNC turning and machining centres.
- Generate CNC programs for popular CNC controllers.
- Describe about linear and angular measurements in metrology.
- Study about the advancement in metrology.

UNIT I INTRODUCTION TO CNC MACHINE TOOLS 9

Evolution of CNC Technology, principles, features, advantages, applications, CNC and DNC concept, classification of CNC Machines – turning centre, machining centre, grinding machine, EDM, types of control systems, CNC controllers, characteristics, interpolators– Computer Aided Inspection, CNC Machine building, structural details, configuration and design, guide ways – Friction, Anti friction and other types of guide ways.

UNIT II DRIVES AND WORK HOLDING DEVICES 9

Spindle drives – DC shunt motor, 3 phase AC induction motor, feed drives –stepper motor, servo principle, DC and AC servomotors, Axis measuring system – synchro, synchro-resolver, gratings, moiré fringe gratings, encoders, inductosysn, laser interferometer, work holding devices for rotating and fixed work parts, economics of CNC, maintenance of CNC machines.

UNIT III CNC PROGRAMMING 9

Coordinate system, structure of a part program, G & M Codes, tool length compensation, cutter radius and tool nose radius compensation, do loops, subroutines, canned cycles, mirror image, parametric programming, machining cycles, programming for machining centre and turning centre for well-known controllers such as Fanuc, Heidenhain, Sinumerik etc., generation of CNC codes from CAM packages.

UNIT IV LINEAR AND ANGULAR MEASUREMENTS 9

Linear Measuring Instruments – Evolution – Types – Classification – Limit gauges – gauge design – terminology – procedure – concepts of interchange ability and selective assembly – Angular measuring instruments – Types – Bevel protractor clinometers angle gauges, spirit levels sine bar – Angle alignment telescope – Autocollimator – Applications.

UNIT V ADVANCES IN METROLOGY 9

Basic concept of lasers Advantages of lasers – laser Interferometers – types – DC and AC Lasers interferometer – Applications – Straightness – Alignment. Basic concept of CMM – Types of CMM – Constructional features – Probes – Accessories – Software – Applications – Basic concepts of Machine Vision System – Element – Applications.

TOTAL: 45 PERIODS

OUTCOMES

At the end of this course the students are expected to

- **CO 1 :** Ability to know about the basic in CNC machineries
- **CO 2 :** Evolution and principle of CNC machine tools and different measurement technologies
- **CO 3 :** Able to write simple programs for CNC machinery
- **CO 4 :** To impart knowledge about linear and angular measurements in metrology
- **CO 5 :** Ability to know about the advancement in metrology.

REFERENCES:

1. HMT, 2005, *Mechatronics*, Tata McGraw-Hill Publishing Company Limited, New Delhi.
2. Warren S.Seamers, 2002, *Computer Numeric Control*, Fourth Edition, Thomson Delmar.
3. Jain R.K. 2005, *Engineering Metrology*, Khanna Publishers.
4. Gupta. I.C., 2005, *Engineering Metrology*, Dhanpatrai Publications.
5. Charles Reginald Shotbolt, 1990, *Metrology for Engineers*, 5th edition, Cengage Learning EMEA.
6. Backwith, Marangoni, Lienhard, 2006, *Mechanical Measurements*, Pearson Education.
7. Peter Smid, 2000, *CNC Programming Hand book*, Industrial Press Inc.
8. Berry Leathan & Jones, 1987, *Introduction to Computer Numerical Control*, Pitman, London.
9. Radhakrishnan P, 2002, *Computer Numerical Control Machines*, New Central Book Agency.

MF1211	**CNC AND METROLOGY LAB**	**L**	**T**	**P**	**C**
		0	**0**	**4**	**2**

OBJECTIVES:

- To impart knowledge in CNC programming for turning and milling operations

- To use measuring systems for the geometrical measurements of gears and threads.
- To know the measurement of Taper Angle using Sine Bar.

CNC LATHE **16**

Plain Turning, Step turning, Taper turning, Threading, Grooving & canned cycle

CNC MILLING MACHINE **16**

Profile Milling, Mirroring, Pocketing, Scaling & canned cycle.

METROLOGY **13**

Measurement of Taper Angle using Sine Bar - Optical profile projector – study of profile of gear tooth, screw threads- Tool maker's microscope –Study cutting tool geometry, screw threads - Tool wear and surface finish measurement - Dimensional measurement of machined components using CMM Machine.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Demonstrate the CNC Lathe machine and carryout simple machining process such as turning, step turning, taper turning, grooving, threading etc.,

CO 2 : Build the coding for Profile Milling, Mirroring, Pocketing using CNC milling machine.

CO 3 : Apply projection techniques to measure the parameters of thread and gear using profile projector.

CO 4 : Measure the tool wear and surface roughness using stylus and CMM.

CO 5 : Interpret the dimension of the machined component using CMM.

LIST OF EQUIPMENTS

S.No.	NAME OF THE EQUIPMENT	Qty.
1.	CNC lathe	1 no
2.	CNC milling machine	1 no
3.	Production type CNC machining centre	1 no
4.	CNC lathe and milling programming software (FANUC controller)	10 Licenses
5.	CNC lathe and milling programming software (Heidenhain controller)	5 Licenses
6.	Optical profile projector	1 no
7.	tool makers microscope	1 no
8.	Measuring gauges for hole depth and height.	
9.	Sine Bar	1 no

MF1221	TECHNICAL SEMINAR	L	T	P	C
		0	0	2	1

OBJECTIVES:

- To enrich the communication skills of the student through presentation of topics in recent advances in engineering/technology.
- To give presentations on recent areas of research in manufacturing engineering in two cycles.

SEMINAR CONTENT **16**

1. Prepare on the specific topic related to developments and innovations in engineering.
2. Present the seminar for fifteen minutes to thirty minutes on the technical topic.
3. Engage in group discussion with the learners.
4. Interact with learners and answer the queries on the topic.
5. Submit the summary of discussions.
6. Evaluation based on the technical presentation, the report and on the interaction during the seminar.

TOTAL: 45 PERIODS

OUTCOMES

Students at the end of course will be

CO 1 : To develop skills to read, write, comprehend and present research papers.
CO 2 : To critically observe the world around and identify a problem that can be solved.
CO 3 : To exhibit skill of presentation both orally and in written form.
CO 4 : To appreciate the importance of team work.
CO 5 : To get hands on experience to doing experimental/ theoretical analysis in synthesis of solution to the problem.

MF1321	PROJECT WORK –PHASE 1	L	T	P	C
		0	0	12	6

OBJECTIVES:

- To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature.
- To develop the methodology to solve the identified problem then publish paper at least in conference.

PROJECT CONTENT

1. The learner individually works on a specific topic approved by the head of the division under the guidance of a faculty member who is familiar in this area of interest.
2. The student can select the specific topic related to the area of manufacturing engineering. The topic may be theoretical or industrial case studies.
3. At the end of the semester, a detailed report on the work done should be submitted which contains clear definition of the identified problem, detailed literature review related to the area of work and methodology for carrying out the work.
4. The learners will be evaluated through a viva-voce examination by a panel of examiners including one external examiner.

TOTAL: 12 PERIODS

OUTCOMES

Student will be able to

CO 1 : Identify the potential problems scientifically in a systematic way
CO 2 : Analyze the problem through detailed literatures clearly to explore the ideas and methods
CO 3 : Justify the limitations of the work and finding feasible scope
CO 4 : Formulate the objectives and methodology to solve the identified problem
CO 5 : Drawing conclusions based on feasibility & methodology in developing solution for the identified problem and also its need in social relevance

		L	T	P	C
MF1421	**PROJECT WORK –PHASE 2**	**0**	**0**	**24**	**12**

OBJECTIVES:

- To solve the identified problem based on the formulated methodology, develop skills to analyze, discuss the test results and make conclusions.

PROJECT CONTENT

1. The learner should continue the project initial phase work on the selected topic as per the formulate methodology under the same supervisor.
2. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department.

3. The learners will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner

TOTAL: 24 PERIODS

OUTCOMES

After the project completion students will be able to

CO 1 : Apply appropriate methodology & standard procedures to carryout/execution of the problem.
CO 2 : Execute the project work in a structured way
CO 3 : Analyze, infer the observations logically
CO 4 : Interpreting the results and justifying it with literatures and objectives
CO 5 : Drawing conclusions from the results and confirm the solution for social benefit.

MF1131	DESIGN FOR MANUFACTURE AND ASSEMBLY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the students learn about tolerance analysis, allocation and geometrical tolerances.
- Guidelines for design for manufacturing and assembly with examples.

UNIT I TOLERANCE ANALYSIS 8

Introduction – Concepts, definitions and relationships of tolerancing – Matching design tolerances with appropriate manufacturing process – manufacturing process capability metrics – Worst care, statistical tolerance Analysis – Linear and Non-Linear Analysis – Sensitivity Analysis – Taguchi's Approach to tolerance design.

UNIT II TOLERANCE ALLOCATION 8

Tolerance synthesis – Computer Aided tolerancing – Traditional cost-based analysis – Taguchi's quality loss function – Application of the Quadratic loss function to Tolerancing – Principles of selective Assembly – Problems.

UNIT III GD&T 10

Fundamentals of geometric dimensioning and tolerancing – Rules and concepts of GD&T – Form controls – Datum systems – Orientation controls – Tolerance of position – Concentricity and symmetry controls – Run out controls – Profile controls.

UNIT IV TOLERANCE CHARTING 9

Nature of the tolerance buildup – structure and setup of the tolerance chart – piece part sketches for tolerance charts – Arithmetic ground rules for tolerance charts –

Determination of Required balance dimensions – Determination of Mean working Dimensions – Automatic tolerance charting – Tolerance charting of Angular surfaces.

UNIT V MANUFACTURING GUIDELINES 10

DFM guidelines for casting, weldment design – Formed metal components – Turned parts – Milled, Drilled parts – Nonmetallic parts – Computer Aided DFM software – Boothroyd and Dewhurst method of DFMA – DCS – Vis/VSA – 3D Dimensional control – Statistical tolerance Analysis Software – Applications.

TOTAL: 45 PERIODS

OUTCOMES

Students at the end of the course will be able

CO 1 : Explain the concepts and methods of tolerance analysis.
CO 2 : Solve the problems related to loss function in tolerancing.
CO 3 : Apply the concepts of GD &T to industrial designs.
CO 4 : Explain the concepts of tolerance charting and tolerance buildup.
CO 5 : Summarize the guidelines of all DFMA concepts.

REFERENCES:

1. Alex Krulikowski, 1997, *Fundamentals GD&T*, Delmar Thomson Learning.
2. C.M. Creveling, 1997, *Tolerance Design – A handbook for Developing Optimal Specifications*, Addison – Wesley.
3. James D. Meadows, 1995, *Geometric Dimensioning and Tolerancing*, Marcel Dekker Inc.
4. James G. Bralla, 1986, *Handbook of Product Design for Manufacturing*, McGraw Hill.
5. Oliver R. Wade, 1967, *Tolerance Control in Design and Manufacturing*, Industrial Press, NY.

MF1132	LEAN MANUFACTURING SYSTEMS AND IMPLEMENTATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To implement lean manufacturing concepts in the factories.
- To apply the various lean tools in industries.

UNIT I LEAN MANUFACTURING 7

Evolution of Lean, Traditional versus Lean Manufacturing, Business of Survival and Growth, Business Model Transformation, Ford Production System, Job Shop Concepts, Concept of Lean, Toyota's foray in Lean.

UNIT II DESIGN - VALUE STREAM MANAGEMENT 9

Definition, VSM Types, Product Family Selection, Value Stream Manager; Current State Map, Process Box, Value Stream Icons, 3 MS - Muda, Mura, Muri - Types of Muda, Future State Map, Value Stream Plan, Process Stability - Loss Reduction -Major Losses Reduction.- Demand Stage, Market Dynamics, Customer Demand, PQ Analysis, PR Analysis; TAKT Time, Pitch, Finished Goods Stock, Cycle Stock, Buffer Stock, Safety Stock.

UNIT III FUNDAMENTAL LEAN TOOLS 11

Flow Stage, Continuous Flow, Cell Layout, Line Balancing, Macro and Micro Motion, Analysis, Standardized Work, Concept of Kaizen, Steps involved in Kaizen Deployment, Industrial Engineering - Concepts and Fundamentals, Kanban Concepts, Types of Kanbans and Practical Application, Concept of Pull, Changeover Time Reduction - External AND Internal, Single Minute Exchange of Die, Quick Die Change, Quality-Vendor, In Process and Customer, Line.

UNIT IV LEAN IMPLEMENTATION 9

Concept of PPM, Pokayoke, Prevention and Detection Types, Maintenance - Preventive, Time Based and Condition Based; Human Development for Lean (Training and Involvement through Autonomous Maintenance) Leveling Stage of Lean Implementation, Production Leveling, Leveling Box, Concept of Water Spider.

UNIT V LEAN METRICS AND LEAN SUSTENANCE 9

Identify Lean Metrics, Steps involved in Goal Setting; Corporate Goals, Kaizen Cloud, identification in VSM, Lean Assessment, Cultural Change, Reviews, Recognition, Improving Targets and Benchmarks.

TOTAL: 45 PERIODS

OUTCOMES

The student will be able to

CO 1 : Identify the production system.
CO 2 : Design the value stream mapping.
CO 3 : Apply lean tools in manufacturing sector.
CO 4 : Apply the lean implementation in production system.
CO 5 : Measure the lean manufacturing levels.

REFERENCES:

1. Askin R G and Goldberg J B, 2003, *Design and Analysis of Lean Production Systems*, John Wiley & Sons, New York.
2. Don Tapping, Tom Luyster and Tom Shuker, 2002, *Value Stream Management*" Productivity Press.

3. Tom Luyster and Don Tapping, 2006, *Creating Your Lean Future State: How to Move from Seeing to Doing*, Productivity Press.
4. Mike Rother and Rick Harris, 2001, *Creating Continuous Flow*, Publisher: Lean Enterprise Institute, Inc.
5. Rick Harris, Chris Harris & Earl Wilson, 2003*, Making Materials Flow*, Publisher: Lean Enterprise Institute, Inc.
6. Micheal Wader, 2002, *Lean Tools: A Pocket guide to Implementing Lean Practices*, Productivity and Quality Publishing Pvt Ltd.
7. Dennis P., 2007, *Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System*, Productivity Press, New York.
8. Liker, J., 2004, *The Toyota Way: Fourteen Management Principles from the World's Greatest Manufacture*, McGraw Hill.
9. Michael, L.G., 2002, *Lean Six SIGMA: Combining Six SIGMA Quality with Lean Production Speed*, McGraw Hill.
10. Ohno, T., 1988, *Toyota Production System: Beyond Large-Scale Production*, Taylor & Francis, Inc.
11. Rother, M., and Shook, J.,1999, *Learning to See: Value Stream Mapping to Add Value and Eliminate MUDA*, Lean Enterprise Institute.

MF1133 MANUFACTURING MANAGEMENT

L	T	P	C
3	0	0	3

OBJECTIVES:

- To study the concepts in facility planning.
- To study types of plant layout and capacity planning methods.
- To study the concepts of Project management.
- To study the concepts and methods in production planning and control.
- 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

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

UNIT III PROJECT MANAGEMENT 9

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

UNIT IV PRODUCTION PLANNING & CONTROL 9

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

UNIT V INVENTORY AND MAINTENANCE MANAGEMENT 9

Introduction to EOQ models, Inventory control techniques – ABC, FSN, VED etc. Types of inventory control – Perpetual, two-bin and periodic inventory system – JIT, SMED, 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

OUTCOMES

On completion of this course the students are expected

CO 1 : To acquire knowledge on facility, and problems associated with it.
CO 2 : To learn the various capacity and layout planning models
CO 3 : To understand the concepts of demand forecasting and project management with relevant case studies.
CO 4 : To understand the concepts of production planning and scheduling.
CO 5 : To understand the various inventory and maintenance management techniques.

REFERENCES:

1. Chary, SN, 2009, *Production and Operations Management*, 4th Edition, SIE, TMH.
2. Chase. RB, N. J. Aquilano, & F. R. Jacobs, 2007, *Operations Management – For Competitive Advantage*, 11th Edition, SIE, TMH.
3. James. B. Dilworth, 1992, *Operations Management – Design, Planning and Control for Manufacturing and Services*, McGraw Hill Inc. Management Series.
4. KanishkaBedi, 2007, *Production and Operations Management*, 2nd Edition, Oxford Higher Education.
5. Lee. J. Krajewski, L. P. Ritzman, & M. K. Malhothra, 2007, *Operations Management – Process and Value Chains*, 8th Edition, PHI/Pearson Education.
6. MelnykDenzler, 1996, *Operations Management – A Value Driven Approach*, Irwin McGraw Hill.

7. Pannererselvam, R, 2012, *Production and Operations Management*", 3rd Edition, PHI.

MF1134	COMPUTER INTEGRATED MANUFACTURING SYSTEMS	L	T	P	C
		3	0	0	3

OBJECTIVES:

This course will enable the Student

- To understand the application of computers in various aspects of Manufacturing viz., Design, Proper planning, Manufacturing cost, Layout & Material Handling system.
- To gain knowledge on how computers are integrated at various levels of planning and manufacturing
- To learn the guidelines and criteria for implementing CAD/CAM Systems and associated software for design, Manufacturing, and a common CAD/CAM data base organized to serve both design and manufacturing.

UNIT I INTRODUCTION **9**

Objectives of a manufacturing system - identifying business opportunities and problems – production systems - Automation in Production Systems - linking manufacturing strategy and systems analysis of manufacturing operations – Manufacturing models and Metrics – Mathematical models of Production Performance – Simple problems – Manufacturing Control – Simple Problems – Basic Elements of an Automated system – Levels of Automation.

UNIT II GROUP TECHNOLOGY & CELLULAR MANUFACTURING SYSTEMS **9**

Part families - classification and coding - Production flow analysis - Cellular Manufacturing – Machine cell design and layout – Quantitative analysis in Cellular Manufacturing – Rank Order Clustering Method - Arranging Machines in a GT cell – Hollier Method – Simple Problems.

UNIT III FLEXIBLE MANUFACTURING SYSTEM (FMS) AND AUTOMATED GUIDED VEHICLE SYSTEM (AGVS) **9**

Components of FMS - Work stations - Computer control and functions - FMS Application Considerations - Alternative Approaches to Flexible Manufacturing - Automated Guided Vehicle System (AGVS) – AGVS Application – Vehicle Guidance technology – Vehicle Management & Safety.

UNIT IV COMPUTER AIDED PLANNING AND CONTROL 9

Production Planning – Material Requirement planning (MRP) - Manufacturing Resource Planning-II (MRP-II) - Enterprise Resource Planning (ERP) - Simple Problems. Inventory Control - Shop floor control - Factory data collection system - Automatic identification system - barcode technology - automated data collection system.

UNIT V COMPUTER MONITORING 9

Types of production monitoring systems - structure model of manufacturing process – process control & strategies - direct digital control - supervisory computer control-computer in QC - contact inspection methods - non-contact inspection method - computer-aided testing - integration of CAQC with CAD/CAM.

TOTAL: 45 PERIODS

OUTCOMES

At the end of this course the students are expected

CO 1 : Explain the basic concepts of CAD, CAM and computer integrated manufacturing systems.

CO 2 : Describe the concept of Group Technology, Identification of Part Families and Quantitative analysis in Cellular Manufacturing Systems.

CO 3 : Explain the concepts of flexible manufacturing system (FMS) and automated guided vehicle (AGV) system.

CO 4 : Discuss the usage of computers in Production Planning & Control.

CO 5 : Explain the types of production monitoring systems and integration of Computer Aided Quality Control with CAD/CAM.

REFERENCES:

1. Mikell. P. Groover, 2001, *Automation, Production Systems and Computer Integrated Manufacturing*, Pearson Education.
2. David Bedworth, 1988, *Computer Integrated Design and Manufacturing*, TMH, New Delhi.
3. Yorem Koren, 2005, *Computer Integrated Manufacturing*, McGraw Hill.
4. Ranky, Paul G., 2005, *Computer Integrated Manufacturing*, Prentice hall of India Pvt. Ltd.
5. P N Rao, 2007, *CAD/CAM Principles and Applications*, TMH Publications.
6. Chris McMahon and Jimmie Browne, 2005, *CAD CAM Principles, Practice and Manufacturing Management*, Pearson Education second edition.
7. James A. Regh and Henry W. Kreabber, 2005, *Computer Integrated Manufacturing*, Pearson Education second edition.

MF1231	RAPID MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To educate students with fundamental and advanced knowledge in the field of Additive manufacturing technology and the associated Aerospace, Architecture, Art, Medical and industrial applications.

UNIT I INTRODUCTION 10

Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM -Classification of AM processes-Benefits- Applications - Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping - Data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation - Software for AM.

UNIT II LIQUID BASED ADDITIVE MANUFACTURING SYSTEMS 7

Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications.

UNIT III SOLID AND POWDER BASED ADDITIVE MANUFACTURING SYSTEMS 10

Fused deposition Modeling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies. Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications.

UNIT IV METAL ADDITIVE MANUFACTURING SYSTEMS 8

Selective Laser Melting, Electron Beam Melting- Shape Deposition Manufacturing (SDM), Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies. Ballastic Particle Manufacturing (BPM)

UNIT V RAPID TOOLING 10

Indirect rapid tooling - silicone rubber tooling, aluminum filled epoxy tooling, spray metal tooling, Direct rapid tooling - direct AIM, copper polyamide, sand casting tooling, laminate tooling, soft tooling Vs hard tooling.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Summarize the fundamental concepts of Additive Manufacturing and its classifications.

CO 2 : Explain the complete fundamentals of working operations, applications & advantages of liquid-based AM process.

CO 3 : Explain the complete fundamentals of working operations, applications & advantages of solid & powder-based AM process.

CO 4 : Describe the various Metal AM process and its applications.

CO 5 : Apply the concepts of creating Tooling for AM Process.

REFERENCES:

1. Chua, C.K., Leong K.F. and Lim C.S., 2010, *Rapid prototyping: Principles and applications*, second edition, World Scientific Publishers.
2. Pham D T and Dimov S S, 2001, *Rapid Manufacturing*, Springer-Verlag, London.
3. Gebhardt, A., 2003, *Rapid prototyping,* Hanser Gardener Publications.
4. Gibson, I., Rosen, D.W. and Stucker, B., 2010, *Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer, NY.
5. Hilton, P.D. and Jacobs, P.F., 2005, *Rapid Tooling: Technologies and Industrial Applications*, Marcel Dekker Inc, New York.
6. Kamrani, A.K. and Nasr, E.A., 2006, *Rapid Prototyping: Theory and practice*, Springer, US.
7. Liou, L.W. and Liou, F.W., 2011, *Rapid Prototyping and Engineering applications: A tool box for prototype development*, CRC Press, New York.

MF1232 MICRO MANUFACTURING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To acquaint the students with the principles, basic machine tools, and developments in the micro manufacturing process
- To study the research trends in the area of micro manufacturing process.

UNIT I MICRO MACHINING I 9

Mechanical Micro machining – Ultra Sonic Micro Machining – Abrasive Jet Micro Machining – Water Jet Micro Machining – Abrasive Water Jet Micro Machining – Micro turning – Chemical and Electro Chemical Micro Machining – Electric discharge micro machining.

UNIT II MICRO MACHINING II 9

Beam Energy based micro machining – Electron Beam Micro Machining – Laser Beam Micro Machining – Electric Discharge Micro Machining – Ion Beam Micro Machining – Plasma Beam Micro Machining – Hybrid Micro machining – Electro Discharge Grinding – Electro Chemical spark micro machining – Electrolytic in process Dressing.

UNIT III NANO POLISHING 9

Abrasive Flow finishing – Magnetic Abrasive Finishing – Magneto rheological finishing – Magneto Rheological abrasive flow finishing - Magnetic Float polishing – Elastic Emission Machining – chemo-mechanical Polishining.

UNIT IV MICRO FORMING AND WELDING 9

Micro extrusion – Micro and Nano structured surface development by Nano plastic forming and Roller Imprinting – Micro bending with LASER – LASER micro welding – Electron beam for micro welding.

UNIT V RECENT TRENDS AND APPLICATIONS 9

Metrology for micro machined components – Ductile regime machining– AE based tool wear compensation– Machining of Micro gear, micro nozzle, micro pins – Applications.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Explain the different micro machining process such as Ultrasonic, Abrasive and water jet, micro turning, electrochemical and electric discharge process.
- **CO 2 :** Describe the special micro machining process such as Electron beam, laser beam, chemical and electical spark and hybrid micromachining process.
- **CO 3 :** Discuss the nano polishing methods such as magneto rheological finishing, chemo mechanical polishing, magnetic float polishing & Abrasive flow finishing
- **CO 4 :** Distinguish the difference between the micro forming and welding process
- **CO 5 :** Summarize the recent trends and applications of micro machining such as ductile regime, –AE based tool wear compensation–Machining of Micro gear, micro nozzle, micro pins

REFERENCES:

1. Bandyopadhyay. A.K., 2008, *Nano Materials*, New age international publishers, New Delhi.
2. Bharat Bhushan, 2010, *Handbook of nanotechnology*, springer, Germany.
3. Jain V.K., 2011, *Introduction to Micro machining,* Narosa Publishing House.
4. Jain V.K., 2002, *Advanced Machining Processes*, Allied Publishers, Delhi.
5. Jain V. K., 2012, *Micro Manufacturing Processes*, CRC Press, Taylor & Francis Group.
6. Janocha H., 2012, *Actuators – Basics and applications*, Springer publishers.
7. Mcgeoug.J.A., 2001, *Micromachining of Engineering Materials*, CRC press.

MF1233	GREEN MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To learn on green manufacturing, recycling and life cycle assessment for environment.

UNIT I SUSTAINABLE MANUFACTURING AND EMS 9

Sustainable Manufacturing - Concepts and Methodologies to Help Promote Industrial Ecology - ISO L4000 series standards - Concepts of ISO 14001 - requirements of ISO 14001 – Environmental Management System benefits - Environmentally Conscious Manufacturing.

UNIT II GREEN MANUFACTURING 9

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

UNIT III RECYCLING 9

Recycling as Universal Resource Policy - Innovation towards Environmental Sustainability in Industry - A Systematic Framework for Environmentally Conscious Design.

UNIT IV ENVIRONMENTAL ATTRIBUTES OF MANUFACTURING 10

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

UNIT V LIFE CYCLE ASSESSMENT 8

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

TOTAL: 45 PERIODS

OUTCOMES

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

- **CO 1 :** Describe the scope of sustainable manufacturing systems in Environmental Management systems and ISO standards
- **CO 2 :** Explain the green manufacturing through green design, costing, accounting and labeling eco systems
- **CO 3 :** Discuss the Universal recycling policies, innovation for sustainable design and framework of environmental conscious design
- **CO 4 :** Summarize the various environmental attributes of manufacturing process, reverse engineering, support systems and supply chain management
- **CO 5 :** Distinguish the life time assessment and risk assessment in recycling of waste.

REFERENCES:

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

MF1234 SUSTAINABLE MANUFACTURING

L	T	P	C
3	0	0	3

OBJECTIVES:

- To introduce the concept of Sustainable Manufacturing to the students.

UNIT I SUSTAINABLE MANUFACTURING 9

Concepts of sustainability and sustainable development – Need for sustainable development - Components of sustainability- Social, Economic, Environmental dimensions - Linkages between technology and sustainability - Sustainable Manufacturing –Scope, Need and Benefits.

UNIT II SUSTAINABLITY TOOLS & DEVELOPMENT 9

Tools and Techniques of Sustainable Manufacturing – Environmental Conscious Quality Function Deployment, Life cycle assessment, Design for Environment, R3 and R6 cycles, Design for Disassembly -Sustainable Product Development – Various Phases.

UNIT III ENVIRONMENT AND SUSTAINABLE DEVELEOPMENT 9

EIA Methods –CML, EI 95 and 99, ISO 14001 EMS and PAS 2050 standards, Environmental Impact parameters - Interactions between energy and technology and their implications for environment and sustainable development.

UNIT IV SUSTAINABLE PRODUCT DESIGN 10

Design for recycling – Eco friendly product design methods – Methods to infuse sustainability in early product design phases – Multi-Criteria Decision Making in Sustainability.

UNIT V SUSTAINABLITY PERFORMANCE 8

Frameworks for measuring sustainability- Indicators of sustainability – Environmental, Economic, Societal and Business indicators - Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment– Corporate Social Responsibility.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Associate the linkages between technology and sustainability.
- **CO 2 :** Adapt the effective utilization of sustainable product development tools.
- **CO 3 :** Design the sustainable product under EIA.
- **CO 4 :** Apply the multi criteria decision making in sustainable development.
- **CO 5 :** Compute sustainability performance through the indicators.

REFERENCES:

1. G. Atkinson, S. Dietz, E. Neumayer, 2007, *Handbook of Sustainable Manufacturing,* Edward Elgar Publishing Limited.
2. D. Rodick, 2007, *Industrial Development for the 21st Century: Sustainable Development Perspectives*, UN New York.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A., 2007, *An Introduction to Sustainable Development*, Earth scan, London.
4. P. Lawn, 2001, *Sustainable Development Indicators in Ecological Economics*, Edward Elgar Publishing Limited.

5. S. Asefa, 2005, *The Economics of Sustainable Development*, W.E. Upjohn Institute for Employment Research.

MF1235	FLUID POWER AUTOMATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To make the students to learn the basics of hydraulics and pneumatics
- To understand and select appropriate pumps and actuators in fluid power.
- To familiarize the various controlling elements in fluid power.
- To train the students in designing the hydraulic and pneumatic circuits using various design procedures.
- To make the students to understand the various methods of control of hydraulic and pneumatic circuits.

UNIT I INTRODUCTION 5

Need for Automation, Hydraulic & Pneumatic Comparison – ISO symbols for fluid power elements, Hydraulic, pneumatics – Selection criteria.

UNIT II FLUID POWER GENERATING/UTILIZING ELEMENTS 8

Hydraulic pumps and motor gears, vane, piston pumps-motors-selection and specification-Drive characteristics – Linear actuator – Types, mounting details, cushioning – power packs – construction. Reservoir capacity, heat dissipation, accumulators – standard circuit symbols, circuit (flow) analysis.

UNIT III CONTROL AND REGULATION ELEMENTS 8

Direction flow and pressure control valves-Methods of actuation, types, sizing of ports-pressure and temperature compensation, overlapped and underlapped spool valves-operating characteristics electro hydraulic servo valves-Different types-characteristics and performance.

UNIT IV CIRCUIT DESIGN 10

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

UNIT V ELECTRO PNEUMATICS & ELECTRONIC CONTROL OF HYDRAULIC AND PNEUMATIC CIRCUITS 7

Electrical control of pneumatic and hydraulic circuits-use of relays, timers, counters, Ladder diagram. Programmable logic control of Hydraulics Pneumatics circuits, PLC ladder diagram for various circuits, motion controllers, use of field busses in circuits. Electronic drive circuits for various Motors.

TOTAL: 45 PERIODS

OUTCOMES

The students will be able to

CO 1 : Understand the working principle of hydraulic and pneumatic components.
CO 2 : Select and design the hydraulic and pneumatic circuits for different applications.
CO 3 : Control hydraulic and pneumatic circuits for various applications.
CO 4 : Solve the problems related to hydraulic and pneumatic circuits.
CO 5 : Solve the problems related to fluid power applications.

REFERENCES:

1. Antony Esposito, 1988, *Fluid Power Systems and control*, Prentice-Hall.
2. Dudbey. A. Peace, 1967, *Basic Fluid Power*, Prentice Hall Inc.
3. E.C.Fitch and J.B.Suryaatmadyn, 1978, *Introduction to fluid logic*, McGraw Hill.
4. Herbert R. Merritt, 1967, *Hydraulic control systems*, John Wiley & Sons, Newyork.
5. Peter Rohner, 1994, *Fluid Power Logic Circuit Design*, Mcmelan Press.
6. Peter Rohner, 1979, *Fluid Power logic circuit design,* The Macmillan Press Ltd.,London.
7. W.Bolton, 2003, *Mechatronics, Electronic control systems in Mechanical and Electrical Engineering*, Pearson Education.

MF1236	**COMPUTER AIDED PRODUCT DESIGN**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- To review the basics of Computer aided design
- To familiarize students on use of modelling tools of CAD software.
- To apply the various design concepts and design tools and techniques while designing a product.
- To understand the product modelling method and its relationship with computer graphics.
- To create awareness on product life cycle management.

UNIT I INTRODUCTION 8

Introduction to Engineering Design – Various phases of systematic design – sequential engineering and concurrent engineering – CAD/CAM hardware and Softwares – software packages for design and drafting.

UNIT II COMPUTER GRAPHICS FUNDAMENTALS AND GEOMETRIC 8

Computer graphics – applications – principals of interactive computer graphics – 2D 3D transformations – projections – curves - Geometric Modelling – types – Wire frame surface and solid modelling – Boundary Representation, constructive solid geometry – Graphics standards – assembly modelling – use of software packages.

UNIT III PRODUCT DESIGN CONCEPTS AND PRODUCT DATA MANAGEMENT 10

Understanding customer needs – Product function modelling – Function trees and function structures – Product tear down methods – Bench marking – Product portfolio – concept generation and selection – Product Data Management – concepts – Collaborative product design– manufacturing planning factor – Customization factor – Product life cycle management.

UNIT IV PRODUCT DESIGN TOOLS AND TECHNIQUES 10

Product modelling – types of product models; product development process tools – TRIZ – Altshuller‘s inventive principles – Modelling of product metrics – Design for reliability – design for manufacturability – machining, casting, and metal forming – design for assembly and disassembly - Design for environment.

UNIT V PRODUCT DESIGN TECHNIQUES 9

FMEA – QFD – Poka Yoke - DOE – Taguchi method of DOE – Quality loss functions – Design for product life cycle.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Understand the design phases and various design hardware and software.
- **CO 2 :** Relating basics of various geometrical feature creation.
- **CO 3 :** Systematically work on each stage in the development of a new product and its management.
- **CO 4 :** Predicting on various factors for various design applications.
- **CO 5 :** Mixing the techniques in the design of new product.

REFERENCES:

1. Biren Prasad, 1996, *Concurrent Engineering Fundamentals Vol.II*, Prentice Hall,1st Edition.
2. David F.,Rogers.J, Alan Adams, 2002, *Mathematical Elements for Computer Graphics*, McGraw Hill, 2ndEdition.
3. Ibrahim Zeid, Sivasubraminian R, 2009, *CAD/CAM theory and Practice*, McGraw Hill, 2ndEdition.
4. James G.Bralla, 1998, *Handbook of Product Design for Manufacturing*, McGraw Hill.
5. Kevin Otto, Kristin Wood, 2004, *Product Design*, Pearson Education.

MF1237	ROBOT DESIGN AND PROGRAMMING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To gain knowledge on growth of robots since origin based on the application.
- To study the kinematics of robot.
- To study the dynamics of robot.
- To expose the students in the various programming techniques in robot and illuminate the curiosity over recent AI techniques.
- To familiarize the sensors and actuators involved in the robot based the application.

UNIT I INTRODUCTION 9

Definition, Need Application, Types of robots – Classifications – Configuration, work volume, control loops, controls and intelligence, specifications of robot, degrees of freedoms, end effectors – types, selection applications.

UNIT II ROBOT KINEMATICS 9

Introduction – Matrix representation Homogeneous transformation, forward and inverse – Kinematic equations, Denvit – Hartenbers representations – Inverse Kinematic relations. Fundamental problems with D-H representation, differential motion and velocity of frames – Jacobian, Differential Charges between frames.

UNIT III ROBOT DYNAMICS AND TRAJECTORY PLANNING 9

Lagrangeon mechanics, dynamic equations for sing, double and multiple DOF robots – static force analysis of robots, Trajectory planning – joint space, Cartesian space description and trajectory planning – third order, fifth order - Polynomial trajectory planning.

UNIT IV ROBOT PROGRAMMING & AI TECHNIQUES 9

Types of Programming – Teach Pendant programming – Basic concepts in A1 techniques – Concept of knowledge representations – Expert system and its components.

UNIT V ROBOT SENSORS AND ACTUATORS 9

Design of Robots – characteristics of actuating systems, comparison, microprocessors control of electric motors, magneto strictive actuators, shape memory type metals, sensors, position, velocity, force, temperature, pressure sensors – Contact and non-contact sensors, infrared sensors, RCC, vision sensors.

TOTAL: 45 PERIODS

OUTCOMES

Students will able to

- **CO 1 :** Apply their knowledge on calculation of end effector coordinate position and angle based on the application.
- **CO 2 :** Calculate force involved in the robot while under operation (i.e. gripping force).
- **CO 3 :** Compute the trajectory of robot based on both joint space and Cartesian space.
- **CO 4 :** Understand the traditional programming in robot and Modern AI Techniques.
- **CO 5 :** Identify appropriate sensors and actuators based on the application.

REFERENCES:

1. Gordon Mair, 1988, *Industrial Robotics*, Prentice Hall, U.K.
2. Groover.M.P. 1996, *Industrial Robotics*, McGraw – Hill International edition.
3. Saeed.B.Niku, 2002, *Introduction to Robotics, Analysis, system, Applications*, Pearson educations.
4. Wesley E Snyder R, 1988, *Industrial Robots, Computer Interfacing and Control*, Prentice Hall International Edition.

		L	T	P	C
MF1238	**INDUSTRIAL DESIGN AND ERGONOMICS**	**3**	**0**	**0**	**3**

OBJECTIVES:

- To introduce to industrial design based on ergonomics.
- To consider ergonomics concept in manufacturing
- To apply ergonomics in design of controls and display.
- To apply environmental factors in ergonomics design.

- To understand aesthetics applicable to manufacturing and product.

UNIT I INTRODUCTION 9

An approach to industrial design, Elements of design structure for industrial design in engineering application in modern manufacturing systems- Ergonomics and Industrial Design: Introduction to Ergonomics, Communication system, general approach to the man-machine relationship, Human component of work system, Machine component of work system, Local environment-light, Heat, Sound.

UNIT II ERGONOMICS AND PRODUCTION 9

Introduction, Anthropometric data and its applications in ergonomic, working postures, Body Movements, Work Station Design, Chair Design. Visual Effects of Line and Form: The mechanics of seeing, Psychology of seeing, Figure on ground effect, Gestalt's perceptions - Simplicity, Regularity, Proximity, Wholeness. Optical illusions, Influences of line and form.

UNIT III DESIGN PRINCIPLES FOR DISPLAY AND CONTROLS 9

Displays: Design Principles of visual Displays, Classification, Quantitative displays, Qualitative displays, check readings, Situational awareness, Representative displays, Design of pointers, Signal and warning lights, colour coding of displays, Design of multiple displays Controls: Design considerations, Controls with little efforts – Push button, Switches, rotating Knobs. Controls with muscular effort – Hand wheel, Crank, Heavy lever, Pedals. Design of controls in automobiles, Machine Tools.

UNIT IV ENVIRONMENTAL FACTORS 9

Colour: Colourand light, Colour and objects, Colour and the eye – after Image, Colour blindness, Colour constancy, Colour terms – Colour circles, Munsel colour notation,reactions to colour and colour combination – colour on engineering equipments, Colour coding, Psychological effects, colour and machine form, colour and style

UNIT V AESTHETIC CONCEPTS 9

Concept of unity, Concept of order with variety, Concept of purpose, Style and environment, Aesthetic expressions - Symmetry, Balance, Contrast, Continuity, Proportion. Style – The components of style, House style, Style in capital good. Introduction to Ergonomic and plant layout softwares.

TOTAL: 45 PERIODS

OUTCOMES

Students at the end of course will be able to

CO 1 : Appreciate ergonomics need in the industrial design.
CO 2 : Apply ergonomics in creation of manufacturing system.

CO 3 : Discuss on design of controls and display.
CO 4 : Consider environmental factors in ergonomics design.
CO 5 : Report on importance of aesthetics to manufacturing system and product.

REFERENCES:

1. Benjamin W.Niebel, 2002, *Motion and Time Study*, Richard, D. Irwin Inc., 7thEdition.
2. Brain Shakel, 1988, *Applied Ergonomics Hand Book*, Butterworth Scientific London.
3. Bridger, R.C., 2003, *Introduction to Ergonomics*, 2ndEdition, McGraw Hill Publications.
4. Martin Helander, 2006, *A Guide to human factors and Ergonomics*, Taylor and Francis.
5. Mayall W.H., 1988, *Industrial design for Engineers*, London Hiffee books Ltd.
6. Sanders and McCormick, 1993, *Human factor Engineering and Design,* McGraw Hill Publications.

MF1331	MATERIALS TECHNOLOGY	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To understand the elastic and plastic behavior of materials.
- To impart knowledge on fracture analysis.
- To familiarize on modern metallic materials.
- To review on polymeric and ceramics materials and their applications.
- To enable student to select material for specific applications.

UNIT I ELASTIC AND PLASTIC BEHAVIOR 10

Elasticity in metals and polymers Anelastic and visco-elastic behaviour – Mechanism of plastic deformation and non-metallic shear strength of perfect and real crystals – Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour – Super plasticity – Deformation of non-crystalline materials.

UNIT II FRACTURE BEHAVIOUR 10

Griffith‘s theory, stress intensity factor and fracture toughness – Toughening mechanisms – Ductile, brittle transition in steel – High temperature fracture, creep –

Larson Miller parameter – Deformation and fracture mechanism maps – Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law. Effect of surface and metallurgical parameters on fatigue – Fracture of non-metallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III SELECTION OF MATERIALS 10

Motivation for selection, cost basis and service requirements – Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications – Computer aided materials selection.

UNIT IV MODERN METALLIC MATERIALS 8

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel – Intermetallics, Ni and Ti aluminides – smart materials, shape memory alloys – Metallic glass and nano crystalline materials.

UNIT V NON METALLIC MATERIALS 7

Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers – Advanced structural ceramics, WC, TIC, TaC, Al2O3, SiC, Si3N4 CBN and diamond – properties, processing and applications.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Get knowledge of mechanism of failure of materials and methods.
- **CO 2 :** Fully appreciate modification of material property to suit the specific requirements.
- **CO 3 :** Express and appreciate the existing materials and development of upcoming new materials.
- **CO 4 :** Have the knowledge to select the various non-metallic materials to suit required applications
- **CO 5 :** Identify and select suitable material for relevant application..

REFERENCES:

1. Ashby M.F., 2005, *Material Selection in Mechanical Design*, 3rd Edition, Butter Worth.
2. ASM, 2002, *Hand book, Vol.11, Failure Analysis and Prevention, (10th Edition)*, ASM.

3. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., 2001, *Selection and use of engineering materials, (3rd edition)*, Butterworth-Heiremann.
4. Thomas H. Courtney, 2000, *Mechanical Behavior of Materials, (2nd edition)*, McGraw Hill.
5. Flinn, R.A., and Trojan, P.K., 1999, *Engineering Materials and their Applications, (4th Edition),* Jaico.
6. George E.Dieter, 1988, *Mechanical Metallurgy*, McGraw Hill.

MF1332	POLYMERS AND COMPOSITE MATERIALS	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce the various processing methods of polymers.
- To enlighten the students about the different types of fibres and matrix materials.
- To analyse the different polymer matrix composites processing methods and their applications.
- To expose the students to the various metal matrix composite processing methods.
- To analyse the various processing techniques of various ceramic matrix composites.

UNIT I PROCESSING OF POLYMERS 9

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

UNIT II FIBERS AND MATRIX MATERIALS 9

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

UNIT III PROCESSING OF POLYMER MATRIX COMPOSITES 9

Thermoset matrix composites: hand layup, spray, filament winding, Pultrusion, resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk

Moulding Compound and sheet Moulding Compound – thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, injection moulding – interfaces in PMCs - structure, properties and application of PMCs – recycling of PMCs.

UNIT IV PROCESSING OF METAL MATRIX COMPOSITES 9

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

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

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

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Get knowledge on various processing methods of polymers.
- **CO 2 :** Get knowledge about various types of fibres and matrix materials.
- **CO 3 :** Understand the various polymer matrix composites processing methods.
- **CO 4 :** Analyse the various processing methods of metal matrix composites.
- **CO 5 :** Analyse the various processing techniques of ceramic matrix composites.

REFERENCES:

1. ASM Handbook – Composites, Vol-21, 2001.
2. Harold Belofsky, 2002, *Plastics, Product Design and Process Engineering*, Hanser Publishers.
3. Jamal Y. Sheikh-Ahmad, 2009, *Machining of Polymer Composites*, Springer, USA.
4. Krishnan K Chawla, 2012, *Composite Materials: Science and Engineering*, International Edition, Springer.
5. Mallick P.K., 2010, *Fiber Reinforced Composites: Materials, Manufacturing and Design*, CRC press, New Delhi.
6. Mallick, P.K. and Newman.S., 2003, *Composite Materials Technology*, Hanser Publishers.
7. Said Jahanmir, Ramulu M. and Philp Koshy, 1999, *Machining of Ceramics and Composites*, Marcel Dekker Inc., New York.

8. Seamour, E.B. 2002, *Modern Plastics Technology*, Prentice Hall.

MF1333	MATERIALS MANAGEMENT	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce to the students the various concepts of materials management.

UNIT I INTRODUCTION 6

Introduction to materials management – Objectives – Functions – Operating Cycle – Value analysis – Make or buy decisions.

UNIT II MANAGEMENT OF PURCHASE 7

Purchasing policies and procedures – Selection of sources of supply – Vendor development – Vendor evaluation and rating – Methods of purchasing – Imports – Buyer – Seller relationship – Negotiations.

UNIT III MANAGEMENT OF STORES AND LOGISTICS 12

Stores function – Location – Layout – Stock taking – Materials handling – Transportation – Insurance – Codification – Inventory pricing – stores management – safety – warehousing – Distribution linear programming – Traveling Salesman problems – Network analysis – Logistics Management.

UNIT IV MATERIALS PLANNING 10

Forecasting – Materials requirements planning – Quantity – Periodic – Deterministic models – Finite production.

UNIT V INVENTORY MANAGEMENT 10

ABC analysis – Aggregate planning – Lot size under constraints – Just in Time (JIT) system.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Describe the various objectives and functions of material management.
CO 2 : Explain the process of purchasing and building vendor relationship.
CO 3 : Solve the problems related to Logistics and Network techniques.
CO 4 : Predict the forecasting techniques in material planning.
CO 5 : Manage the inventory management department independently.

REFERENCES:

1. Dr. R. Kesavan, C.Elanchezian and T.SundarSelwyn, 2005, *Engineering Management,* Eswar Press.
2. Dr.R. Kesavan, C.Elanchezian and B.Vijaya Ramnath, 2008, *Production Planning and Control*, Anuratha Publications, Chennai.
3. G. Reghuram, N. Rangaraj, 2006, *Logistics and supply chain management – cases and concepts*, Macmillan India Ltd.
4. Gopalakrishnan.P, 2005, *Handbook of Materials Management*, Prentice Hall of India.
5. Guptha P.K. and Heera, 2007, *Operations Research*, Suttan Chand & Sons.
6. Lamer Lee and Donald W.Dobler, 2006, *Purchasing and Material Management, Text and cases*, Tata McGraw Hill.

MF1334 MATERIALS TESTING AND CHARACTERIZATION

L	T	P	C
3	0	0	3

OBJECTIVES:

- To provide understanding of techniques of microstructure and crystal structure evaluation of materials
- To introduce tools for analysis of microstructure and surface topography of materials.
- To understand the techniques of chemical and thermal analysis of materials.
- To gain knowledge in various static mechanical testing methods.
- To gain knowledge in various dynamic mechanical testing methods.

UNIT I MICRO AND CRYSTAL STRUCTURE ANALYSIS 10

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

UNIT II ELECTRON MICROSCOPY 9

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

UNIT III CHEMICAL AND THERMAL ANALYSIS 9

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

UNIT IV MECHANICAL TESTING – STATIC TESTS 8

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

UNIT V MECHANICAL TESTING – DYNAMIC TESTS 9

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

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : To characterize the engineering materials.
CO 2 : Know the fundamental principle of Top-notch characterization tools.
CO 3 : Choose appropriate mechanical static testing methods.
CO 4 : Choose appropriate mechanical dynamic testing methods
CO 5 : Identify the crystal structure and analysis can be made.

REFERENCES:

1. ASM Hand book, 2004, *Materials characterization*, Vol – 10.
2. Culity B.D., Stock S.R& Stock S., 2001, *Elements of X ray Diffraction, (3rd Edition)*, Prentice Hall.
3. Davis J. R., 2004, *Tensile Testing*, 2nd Edition, ASM International.
4. Davis, H.E., Hauck G. & Troxell G.E., 1982, *The Testing of engineering Materials*, (4th Edition), McGraw Hill, College Divn.
5. Dieter G.E., 1988, *Mechanical Metallurgy*, (3rd Edition), McGraw Hill.
6. Goldsten,I.J., Dale.E., Echin.N.P.& Joy D.C., 2000, *Scanning Electron Microscopy & X ray- Micro Analysis*, (2nd Edition), Plenum Publishing Corp.
7. Grundy P.J. and Jones G.A., 1970, *Electron Microscopy in the Study of Materials*, Edward Arnold Limited.
8. Morita.S, Wiesendanger.R, and Meyer.E, 2002, *Non-contact Atomic Force Microscopy,* Springer.

9. Newby J., 1989, *Metals Hand Book- Metallography & Micro Structures*, (9th Edition), ASM International.
10. Suryanarayana A. V. K., 2007, *Testing of metallic materials*, (2nd Edition), BS publications.

MF1335	MANUFACTURING SYSTEM SIMULATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- Introduce computer simulation technologies and techniques.
- Introduce concepts of modeling layers of society's critical infrastructure networks.
- Build tools to view and control simulations and their results.

UNIT I INTRODUCTION 9

Systems and modeling – statistical models in simulation –discrete and continuous system –Monte Carlo Simulation. Simulation of Single Server Queuing System. Simulation of manufacturing shop Simulation of Inventory System.

UNIT II RANDOM NUMBERS 9

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

UNIT III RANDOM VARIATES 9

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

UNIT IV ANALYSIS OF SIMULATION DATA 9

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

UNIT V SIMULATION LANGUAGES 9

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

TOTAL: 45 PERIODS

OUTCOMES

At the end of this course the students are expected to

CO 1 : Understand the statistical models in simulation and evaluate the queuing networks in the context of manufacturing

CO 2 : Generate Random numbers and pseudo random numbers to execute a simulation model

CO 3 : Generate Random variates using inverse transform, direct transform and convolution method acceptance rejection techniques

CO 4 : Develop a suitable model to analyze the simulation data to find the optimized solution in manufacturing

CO 5 : Design a simulation model using vaious simulation languages viz… WITNESS, FLEXSIM, ARENA and SIMQUICK languages.

REFERENCES:

1. Geoffrey Gordon, 2002, *System Simulation*, 2nd Edition, Prentice Hall, India.
2. Jerry Banks & John S.Carson, Barry L Nelson, 2005, *Discrete event system simulation*, Prentice Hall.
3. Law A.M, 2010, *Simulation Modelling and Analysis*, Tata Mc Graw Hill.
4. NarsinghDeo, *System Simulation with Digital Computer*, Prentice Hall.
5. Pidd, M, 2007, *Computer Simulation in Management Science*, John Wiley & Sons, Inc.

MF1336	FINITE ELEMENT ANALYSIS IN MANUFACTURING	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To introduce to fundamentals of finite element techniques.
- To analyse one dimensional phenomena using finite element techniques.
- To analyse 2D and 3D phenomena using finite element techniques.
- To impart knowledge about various factors, pre-processing and post-processing steps with implementation of computer in FEA.
- To impart knowledge in the area of finite element methods and its application in manufacturing.

UNIT I INTRODUCTION 6

Fundamentals – Initial, boundary and eigen value problems – weighted residual, Galerkin and Rayleigh Ritz methods - Integration by parts – Basics of variational formulation – Polynomial and Nodal approximation.

UNIT II ONE DIMENSIONAL ANALYSIS 10

Steps in FEM – Discretization. Interpolation, derivation of elements characteristic matrix, shape function, assembly and imposition of boundary conditions-solution and post processing – One dimensional analysis in solid mechanics and heat transfer.

UNIT III SHAPE FUNCTIONS AND HIGHER ORDER FORMULATIONS 10

Shape functions for one- and two-dimensional elements- Three noded triangular and four nodded quadrilateral element Global and natural co-ordinates—Nonlinear analysis – Isoparametric elements – Jacobian matrices and transformations – Basics of two-dimensional, plane stress, plane strain and axisymmetric analysis.

UNIT IV COMPUTER IMPLEMENTATION 9

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.

UNIT V ANALYSIS OF PRODUCTION PROCESSES 10

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: 45 PERIODS

OUTCOMES

Students will be able to

- **CO 1 :** Perform the fundamentals of solving Finite element problems.
- **CO 2 :** Discretize and solve one-dimensional solid mechanics and heat transfer problems in FEA.
- **CO 3 :** Identify the impact of shape functions and usage of higher order formulation in converging solution to FEA problem.
- **CO 4 :** Implementation of computer on solving FEA based problems.
- **CO 5 :** Structuring a production process through FEA and control it’s parameters.

REFERENCES:

1. Bathe, K.J., 1990, *Finite Element procedures in Engineering Analysis*, Prentice Hall, New Jersy.

2. Kobayashi,S, Soo-ik-Oh and Altan,T, 1989, *Metal Forming and the Finite Element Methods*, Oxford University Press.
3. Lewis R.W. Morgan, K, Thomas, H.R. and Seetharaman, K.N., 1994, *The Finite Element Method in Heat Transfer Analysis*, John Wiley.
4. Rao, S.S., 2005, *Finite Element method in engineering*, Pergammon press.
5. Reddy, J.N. An Introduction to the Finite Element Method, McGraw Hill,2005.
6. Seshu P., 2004, *Textbook of Finite Element Analysis*, PHI Learning Pvt. Ltd.

MF1337 RESEARCH METHODOLOGY AND IPR

L	T	P	C
3	0	0	3

OBJECTIVES:

- To impart knowledge and skills required for Research and IPR:
- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 9

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 9

Effective literature studies approaches, analysis, plagiarism, and research ethics

UNIT III TECHNICALWRITING /PRESENTATION 9

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 9

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 9

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

TOTAL: 45 PERIODS

OUTCOMES

On completion of this course the students are expected

- **CO 1 :** Ability to formulate research problem
- **CO 2 :** Ability to carry out research analysis
- **CO 3 :** Ability to follow research ethics
- **CO 4 :** Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
- **CO 5 :** Ability to understand about IPR and filing patents in R & D.

REFERENCES:

1. Asimov, 1962, *Introduction to Design*, Prentice Hall.
2. Halbert, 2007, *Resisting Intellectual Property*", Taylor & Francis Ltd.
3. Mayall, 1992, *Industrial Design*, McGraw Hill.
4. Niebel, 1974, *Product Design*, McGraw Hill.
5. Ranjit Kumar, 2nd Edition, 2010, *Research Methodology: A Step by Step Guide for beginners,* SAGE Publications.

MF1338	NON-DESTRUCTIVE TESTING AND EVALUATION	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To stress the importance of NDT in engineering.

UNIT I **NON-DESTRUCTIVE TESTING: AN INTRODUCTION, VISUAL INSPECTION & LIQUID PENETRANT TESTING** **6**

Introduction to various non-destructive methods, Comparison of Destructive and Non destructive Tests, Visual Inspection, Optical aids used for visual inspection, Applications. Physical principles, procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods-water washable, Post – Emulsification methods, Applications.

UNIT II **EDDY CURRENT TESTING & ACOUSTIC EMISSION** **10**

Principles, Instrumentation for ECT, Absolute, differential probes, Techniques – High sensitivity techniques, Multi frequency, Phased array ECT, Applications. Principle of

AET, Instrumentation, Applications - testing of metal pressure vessels, Fatigue crack detection in aerospace structures.

UNIT III MAGNETIC PARTICLE TESTING & THERMOGRAPHY 10

Principle of MPT, procedure used for testing a component, Equipment used for MPT, Magnetizing techniques, Applications. Principle of Thermography, Infrared Radiometry, Active thermography measurements, Applications – Imaging entrapped water under an epoxy coating, Detection of carbon fiber contaminants.

UNIT IV ULTRASONIC TESTING 10

Principle, Ultrasonic transducers, Ultrasonic Flaw detection Equipment, Modes of display A- scan, BScan, C- Scan, Applications, Inspection Methods - Normal Incident Pulse-Echo Inspection, Normal Incident Through-transmission Testing, Angle Beam Pulse-Echo testing, TOFD Technique, Applications of Normal Beam Inspection in detecting fatigue cracks, Inclusions, Slag, Porosity and Intergranular cracks - Codes, standards, specification and procedures and case studies in ultrasonics test.

UNIT V RADIOGRAPHY 9

Principle of Radiography, x-ray and gamma ray sources- safety procedures and standards, Effect of radiation on Film, Radiographic imaging, Inspection Techniques – Single wall single image, Double wall Penetration, Multiwall Penetration technique, Real Time Radiography - Codes, standards, specification and procedures and case studies in Radiography test. Case studies on defects in cast, rolled, extruded, welded and heat-treated components – Comparison and selection of various NDT techniques.

TOTAL: 45 PERIODS

OUTCOMES

Students will be able to

CO 1 : Describe the overview of various NDT methods for detecting defects in materials using visual inspection and liquid penetrant testing methods

CO 2 : Discuss the principle, process, advantages and disadvantages of Eddy current testing and Acoustic emission methods

CO 3 : Comprehend the principle, process, advantages and disadvantages of Magnetic particle testing and Thermography methods

CO 4 : Explain the principle, process, advantages and disadvantages of ultrasonic testing

CO 5 : Discuss the principle, interaction and various imaging techniques of radiography and fluoroscopy with industrial applications.

REFERENCES:

1. Baldev Raj, Jeyakumar,T., Thavasimuthu,M., 2002, *Practical Non Destructive Testing,* Narosa publishing house, New Delhi.
2. Krautkramer. J., 1996, *Ultra Sonic Testing of Materials*, 1st Edition, Springer Verlag Publication, New York.
3. Peter J. Shull, 2002, *Non Destructive Evaluation: Theory, Techniques and Application,* Marcel Dekker, Inc., New York.

		L	T	P	C
OMF151	**3D PRINTING AND DESIGN**				
	(AICTE Recommended Course in Emerging Area)	**3**	**0**	**0**	**3**

OBJECTIVES:

The course is designed

- To impart knowledge and skills related to 3D printing technologies.
- To select material and equipment for various 3D printing products.
- To develop a product using this technique in Industry 4.0 environment.

UNIT I 3D PRINTING INTRODUCTION 9

Introduction, Process, Classification, Advantages, Additive V/s Conventional Manufacturing processes. CAD Data formats, Data translation, Data loss, STL format. Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools.

UNIT II ADDITIVE MANUFACTURING TECHNIQUES 10

Principle, pre-build process, part-building and post build processes, materials, advantages, limitations and applications for Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology. Process, Process parameter, Process Selection for various applications.

UNIT III AM MATERIALS 10

Polymers, Metals, Non-Metals, Ceramics - Various forms of raw material- Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties -Support Materials.

UNIT IV DESIGN OF ADDITIVE MANUFACTURING EQUIPMENT 10

Process Equipment- Design and process parameters - Governing Bonding Mechanism - Common faults and troubleshooting - Process Design.

UNIT V POST PROCESSING & PRODUCT INSPECTION 6

Post Processing Requirement and Techniques - Inspection and testing - Defects and their causes.

TOTAL: 45 PERIODS

OUTCOMES

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

CO 1 : Explain how to select a 3D printing process for an application.
CO 2 : Explain the principle, process, advantages and disadvantages of various AM techniques.
CO 3 : Select a specific AM material for the suitable application.
CO 4 : Develop CAD models, Printing Mechanism for 3D printing.
CO 5 : Explain various post processing & inspection techniques in AM.

REFERENCES:

1. Lan Gibson, David W. Rosen and Brent Stucker, 2010, *Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing*, Springer.
2. Andreas Gebhardt, 2011, *Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing*", Hanser Publisher.
3. Soloman S, 2020, *3D Printing and Design*, Khanna Publishing House, Delhi.
4. CK Chua, Kah Fai Leong, 2018, *3D Printing and Rapid Prototyping- Principles and Applications*", World Scientific.
5. J.D. Majumdar and I. Manna, 2013, *Laser-Assisted Fabrication of Materials*, Springer Series in Material Science.
6. L. Lu, J. Fuh and Y.S. Wong, 2001, *Laser-Induced Materials and Processes for Rapid Prototyping*, Kulwer Academic Press.
7. Zhiqiang Fan & Frank Liou, 2012, *Numerical Modelling of the Additive Manufacturing (AM) Processes of Titanium Alloy*, InTech.

OMF152	**COMPOSITE MATERIALS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

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

UNIT II REINFORCEMENTS 9

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

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

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

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

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

UNIT V STRENGTH 9

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

TOTAL: 45 PERIODS

OUTCOMES

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

CO 1 : Know the characteristics of composite materials and effect of reinforcement in composite materials.
CO 2 : Know the various reinforcements used in composite materials.
CO 3 : Understand the manufacturing processes of metal matrix composites.
CO 4 : Understand the manufacturing processes of polymer matrix composites.
CO 5 : Analyze the strength of composite materials.

REFERENCES:

1. Cahn R.W. , 2009, *Material Science and Technology – Vol 13 – Composites*, Weinheim, VCH, West Germany.
2. Callister, W.D Jr., & Balasubramaniam R, 2007, *Materials Science and Engineering, An introduction*, John Wiley & Sons, NY.
3. Chawla K.K., 2013, *Composite Materials,* Springer-Verlag New York.
4. Lubin.G, 2013, *Hand Book of Composite Materials*, Springer US.

OMF153	OPERATIONS RESEARCH	L	T	P	C
		3	0	0	3

OBJECTIVES:

- To solve linear programming problem and solve using graphical method.
- To solve LPP using simplex method.
- To solve nonlinear & dynamic problems.
- To solve project management problems.

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models.

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

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

UNIT III NON-LINEAR PROGRAMMING & NETWORK MODELS 9

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

UNIT IV SEQUENCING AND INVENTORY MODELS 9

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

UNIT V DYNAMIC PROGRAMMING AND SIMULATION 9

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

TOTAL: 45 PERIODS

OUTCOMES

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

- **CO 1 :** To formulate linear programming problem and solve using graphical method.
- **CO 2 :** To solve LPP using simplex method
- **CO 3 :** To apply the concept of non-linear programming
- **CO 4 :** To solve project management problems
- **CO 5 :** To model the real-world problem and simulate it.

REFERENCES:

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