

*With effect from the Academic year 2023-2024*



**DEPARTMENT OF MECHANICAL ENGINEERING**

*Scheme of Instruction  
and  
Syllabus of*

**M.E. (Mechanical Engineering)  
PRODUCTION ENGINEERING  
Full Time & CEEP**

*With effect from the Academic Year 2023-2024*



**UNIVERSITY COLLEGE OF ENGINEERING  
(Autonomous)  
Osmania University  
Hyderabad – 500 007, TS, INDIA**



## **UNIVERSITY COLLEGE OF ENGINEERING, OSMANIA UNIVERSITY**

### **VISION OF THE INSTITUTE**

The Vision of the Institute is to generate and disseminate knowledge through a harmonious blending of Science, Engineering and Technology. To serve the society by developing a modern technology in students' heightened intellectual, cultural, ethical and humane sensitivities, fostering a scientific temper and promoting professional and technological expertise.

### **MISSION OF THE INSTITUTE**

- To achieve excellence in Teaching and Research.
- To generate, disseminate and preserve knowledge.
- To enable empowerment through knowledge and information.
- Advancement of knowledge in Engineering, Science and Technology.
- Promote learning in free thinking and innovative environment.
- Cultivate skills, attitudes to promote knowledge creation.
- Rendering socially relevant technical services for the community.
- To impart new skills of technology development.
- To inculcate entrepreneurial talents and technology appreciation programmes.
- Technology transfer and incubation.

## **DEPARTMENT OF MECHANICAL ENGINEERING**

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### **VISION OF THE DEPARTMENT**

To generate and disseminate knowledge in Mechanical Engineering and nurture professional, technical and scientific temper for serving the needs of the industry, research organizations and society.

### **MISSION OF THE DEPARTMENT**

- Create technically competent mechanical engineers to suit the changing needs of global industry and society.
- To cultivate skills, attitudes to promote knowledge creation and technology development.
- Interact with prominent educational institutions and R&D organizations for enhancing teaching, research and consultancy services.

**DEPARTMENT OF MECHANICAL ENGINEERING**  
**M.E (Production Engineering)**  
**PROGRAM EDUCATIONAL OBJECTIVES**

<b>PEO-1</b>	To provide students with in depth knowledge on advanced areas of production engineering enabling them identify, analyse and solve complex engineering problems using computational tools.
<b>PEO-2</b>	To enable students to carryout innovative and independent research work in production engineering with multidisciplinary applications duly considering economical and financial factors for solving industrial and societal needs.
<b>PEO-3</b>	To provide graduates with professional skills like communication, writing, presentation and management capabilities that enable them to become world class professionals, administrators and academicians.
<b>PEO-4</b>	To imbibe moral ethics and enthusiasm in students to engage in as a lifelong learning process.

**PROGRAM OUTCOMES**

At the end of the programme the student shall be able to:

<b>PO-1</b>	Ability to independently carry out research/ investigation and development work to solve practical problems
<b>PO-2</b>	ability to write and present a substantial technical report/document
<b>PO-3</b>	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program
<b>PO-4</b>	Apply the appropriate knowledge, techniques, skills and modern tools to solve manufacturing related problems
<b>PO-5</b>	Ability to collaborate and develop optimal solutions for manufacturing a product.

**AICTE-Model Curriculum**  
**Scheme of Instructions & Examination**  
**M.E. (Mechanical Engineering) 4 Semesters (Full Time)**

S.No	Subject	Scheme of Studies per Week		Max. Marks		Credits
		L	P	CIE	SEE	
<b>Semester-I</b>						
1.	Core I	3	-	40	60	3
2.	Core II	3	-	40	60	3
3.	Core III	3	-	40	60	3
4.	Program Elective I	3	-	40	60	3
5.	Program Elective II	3	-	40	60	3
6.	Program Elective III	3	-	40	60	3
7.	Laboratory I	0	2	50	--	1
8.	Seminar	0	2	50	--	1
	<b>Total</b>	<b>18</b>	<b>4</b>	<b>340</b>	<b>360</b>	<b>20</b>
<b>Semester-II</b>						
1.	Core IV	3	-	40	60	3
2.	Core V	3	-	40	60	3
3.	Core VI	3	-	40	60	3
4.	Program Elective IV	3	-	40	60	3
5.	Program Elective V	3	-	40	60	3
6.	Open Elective	3	-	40	60	3
7.	Laboratory II	-	2	50	--	1
8.	Laboratory III	-	2	50	--	1
9.	*Mini Project	-	4	50	--	2
	<b>Total</b>	<b>18</b>	<b>8</b>	<b>390</b>	<b>360</b>	<b>22</b>
<b>Semester-III</b>						
1.	Audit Course I	2	-	40	60	0
2.	Audit Course II	2	-	40	60	0
3.	Dissertation Phase I	-	20	100	--	10
	<b>Total</b>	<b>4</b>	<b>20</b>	<b>180</b>	<b>120</b>	<b>10</b>
<b>Semester-IV</b>						
1.	Dissertation Phase II	0	32	100	100	16
	<b>Grand Total</b>	<b>40</b>	<b>64</b>	<b>1010</b>	<b>940</b>	<b>68</b>

Note:

- i. Dissertation-II has two parts, CIE - I and CIE – II, at the end of 8th week and 16th week respectively for evaluation of 50 marks each.
- ii. Audit Courses will be offered in ONLINE mode and SEE will be conducted in Computer Based Test Mode.
- iii. Research Methodology in Mechanical Engineering will be offered as an Audit Course for all PG Programs.
- iv. Engineering Research Methodology Workshop will be conducted for one week for Ph.D. scholars.

*If the student is selected for Industry Internship, then he/she has to complete the required courses of Program elective V and Open Elective through **SWAYAM-NPTEL MOOCS** Courses for getting the required credits. However the students are required to consult Head & CBoS (Autonomous) for due approval, before he/ she registers for the course in **SWAYAM-NPTEL** portal.*

M.E. (Mechanical Engineering) Specialization: **Production Engineering**

Type of Course	Course Code	Course Name	Contact hours per week		Scheme of Examination		Credits
			L	P	CIE	SEE	
<b>SEMESTER-I</b>							
Core-I	ME101	Advanced Casting and Joining Processes	3	-	40	60	3
Core-II	ME102	Theory of Metal Forming	3	-	40	60	3
Core-III	ME103	Theory of Metal Cutting	3	-	40	60	3
Program Elective-I	ME111	Flexible Manufacturing Systems	3	-	40	60	3
	ME112	Computer Integrated Manufacturing					
	ME113	Manufacturing Automation					
	ME114	Manufacturing Management					
	ME115	Industry 4.0					
Program Elective-II	ME116	Mechatronics & Industrial Robotics	3	-	40	60	3
	ME117	Theory of Elasticity and Plasticity					
	ME118	Surface Engineering					
	ME119	Quality and Reliability Engineering					
	ME120	Advanced Metrology					
Program Elective-III	ME121	Tool Engineering	3	-	40	60	3
	ME122	Product Design Reengineering					
	ME123	Tribology					
	ME124	Optimization Techniques					
	ME125	Sustainable Manufacturing					
Lab-I	ME151	Production Engineering Lab	0	2	50	--	1
Lab-II	ME161	Seminar	0	2	50	--	1
<b>TOTAL</b>			<b>18</b>	<b>4</b>	<b>340</b>	<b>360</b>	<b>20</b>

SEMESTER-II							
Core-IV	ME104	Product Design and Process Planning	3	-	40	60	3
Core-V	ME105	Computer Aided Manufacturing	3	-	40	60	3
Core-VI	ME106	Additive Manufacturing Technologies and Applications	3	-	40	60	3
Program Elective-IV	ME126	Experimental Techniques and Data Analysis	3	-	40	60	3
	ME127	Non-Destructive Evaluation Techniques					
	ME311	Finite Element Techniques					
	ME128	Design for Manufacturing and Assembly					
	ME129	Machine Tool Dynamics					
Program Elective-V	ME130	Smart Materials and MEMS	3	-	40	60	3
	ME131	Micro and Nano Manufacturing					
	ME132	Manufacturing of Non-metallic Products					
	ME133	High Speed Machining					
	ME405	Material Science and Technology					
Open Elective	OE941BM	Medical Assistive Devices	3	-	40	60	3
	OE942BM	Medical Imaging Techniques					
	OE941CE	Green Building Technology					
	OE942CE	Cost Management of Engineering Projects					
	OE941CS	Business Analytics					
	OE941EC	Elements of Embedded Systems					
	OE941EE	Waste to Energy					
	OE942EE	Power Plant Control and Instrumentation					
	OE941ME	Operations Research					
	OE942ME	Composite Materials					

	OE943ME	Industrial Safety					
	OE941LA	Intellectual Property Rights					
Core	MC070	Mini Project	-	4	50	-	2
Lab-III	ME152	Computational Lab for PE	-	2	50	--	1
Lab-IV	ME153	Manufacturing Simulation Lab	-	2	50	--	1
<b>TOTAL</b>			<b>18</b>	<b>8</b>	<b>390</b>	<b>360</b>	<b>22</b>
<b>SEMESTER-III</b>							
Audit Course I	AC030 ME	Research Methodology in Mechanical Engineering	2	-	40	60	0
Audit Course II	AC 031	English for Research Paper Writing	2	-	40	60	0
	AC 032	Disaster Mitigation & Management					
	AC 033	Sanskrit for Technical Knowledge					
	AC 034	Value Education					
	AC 035	Stress Management by Yoga					
	AC 036	Personality Development Through Life Enlightenment Skills					
	AC 037	Constitution of India					
	AC 038	Pedagogy Studies					
	AC 039	E-Waste Management					
	ME181	Dissertation Phase I	-	20	100	--	10
<b>TOTAL</b>			<b>4</b>	<b>20</b>	<b>180</b>	<b>120</b>	<b>10</b>
<b>SEMESTER-IV</b>							
	ME182	Dissertation Phase II	0	32	100	100	16
<b>GRAND TOTAL</b>			<b>40</b>	<b>64</b>	<b>1010</b>	<b>940</b>	<b>68</b>



**SEMESTER-I**

<b>ME101</b>	<b>ADVANCED CASTING &amp; JOINING PROCESSES</b>					
<b>(CORE - I)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To familiarize students with the design principles of gates and risers to obtain defect free casting
- To study casting and welding metallurgy concepts for obtaining sound castings and weldments respectively
- To provide knowledge on recent trends in casting and welding processes and their automation

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
C01	Design gating system elements for sound casting	L4
C02	Apply the knowledge of casting metallurgy to minimize casting defects	L3
C03	Identify the recent trends in casting processes and automation of foundry	L2
C04	Apply welding metallurgy concepts to design defect free welds	L3
C05	Identify the recent trends in welding processes and its automation	L2

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	3	2	3	
<b>CO2</b>	2	3	1	3	1
<b>CO3</b>	1	2	2	2	1
<b>CO4</b>	2	3	1	3	1
<b>CO 5</b>	1	2	2	2	1

**UNIT - I**

**Casting Metallurgy:** Solidification of pure metal and alloys, grain structure of cast metals, shrinkage in cast metals, progressive and directional solidification, Degassing of the melt-casting defects, refractories, metallurgical control, Inoculation, malleabilisation. Castability of steel, Cast Iron- Heat treatment of cast steel, cast iron, stress relieving, solution treatment, age hardening of castings.

## **UNIT - II**

**Casting Design:** Heat transfer between metal and mould - Design considerations in casting – Designing for directional solidification and minimum stresses- principles and design of gating and risers.

## **UNIT - III**

**Recent Trends in Casting and Foundry Layout:** 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:** Heat affected Zone and its characteristics –Carbon Equivalent of Plain and alloy steels-Schaeffler diagram, Delta Ferrite, Austenite, pearlite, Martensite. Effect of Alloying elements on microstructure- Residual stress – Distortion and its control -Weld cracks – cold and hot cracks; Liquation cracks, Hydrogen Induced cracks, Lamellar cracks.Pre and post welding heat treatments –weld joint design – welding defects – Weldability of steels, cast iron, stainless steel.

## **UNIT - V**

**Recent Trends In Welding:** Friction welding, friction stir welding, explosive welding, diffusion bonding, high frequency induction welding, ultrasonic welding, electron beam welding, Laser beam welding, Plasma welding, Electro slag 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 welding.

### **Suggested Reading:**

1. Parmer R.S., “Welding Engineering and Technology”, Second Edition, Khanna Publishers, 2013
2. Srinivasan N.K., “Welding Technology”, Fourth Edition, Khanna Publishers, 2002
3. Heinelooper & Rosenthal, “Principles of Metal Casting”, Fourth Edition, Tata McGraw Hill, 2008.
4. Jain P.L., “Principles of Foundry Technology”, Fourth Edition, Tata McGraw Hill Publishers, 2003
5. Carry B., “Modern Welding Technology”, Sixth Edition, Prentice Hall Pvt Ltd., 2005.
6. Cornu.J. “Advanced welding systems” – Volumes I, II and III, JAICO Publishers, 1994.
7. Lancaster.J.F. – “Metallurgy of welding”, Sixth Edition, George Alien & Unwin Publishers, 1999.
8. ASM Handbook, Vol 15, Casting, 2004

<b>ME102</b>	<b>THEORY OF METAL FORMING</b>					
<b>(CORE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:** After completion of the course student will be able to

- To understand the fundamentals of metal forming processes.
- To learn the basic principle of sheet metal and bulk metal deformation.
- To know the principle and applications of un-conventional forming techniques.

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Design gating system elements for sound casting	L4
CO2	Apply the knowledge of casting metallurgy to minimize casting defects	L3
CO3	Identify the recent trends in casting processes and automation of foundry	L2
CO4	Apply welding metallurgy concepts to design defect free welds	L3
CO5	Identify the recent trends in welding processes and its automation	L2

### Program Articulation Matrix

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	3	2	3	
<b>CO2</b>	2	3	1	3	1
<b>CO3</b>	1	2	2	2	1
<b>CO4</b>	2	3	1	3	1
<b>CO 5</b>	1	2	2	2	1

### UNIT-I

**Fundamentals of Metal Forming:** Classification of metal forming processes, Mechanism of plastic deformation, Factors affecting plastic deformation, Strain hardening behavior. Recovery, Recrystallization and grain growth. Ideal & Practical stress-strain curves. Cold working, warm working and hot working. Plasticity cycle. Yield criteria.

## **UNIT-II**

Sheet Metal Working: Formability tests for sheet metals. Erichsen and Fukui tests. F.L.D. and Shape analysis concepts. Sheet metal dies, Process parameters and estimation of loads in shearing, bending, deep drawing and spinning operations. Superplastic forming, Stretch forming. Fine blanking, Incremental forming.

## **UNIT-III**

Analysis of plastic deformation: 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. Hydrostatic Extrusion. Metal working lubricants.

## **UNIT-IV**

Powder Metallurgy 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,

## **UNIT-V**

Unconventional Forming: High energy rate forming. Merits and limitations of HERF Processes. Principle, merits, limitations and applications of Explosive forming, electromagnetic forming, electro-hydraulic forming and water hammer forming. Forming with rubber pads.

### **Suggested Reading:**

1. Geoffrey W. Rowe, "An introduction to the Principles of Metal Working", First Edition, St Martin's Press, London, 1965.
2. Serope Kalpak Jain, "Mechanical Processing of Materials", D.Van Nostr and Company, Inc., First Edition, Princeton, New Jersey, 1955.
3. Surender Kumar, "Principles of Metal Working", Second Edition, Oxford & IBH Publishing Co. Pvt. Ltd., 1985.
4. P.C. Sharma, "A Text Book of Production Engineering", Eleventh Edition, S.Chand & Co. Ltd. New Delhi, 2013.
5. G.E. Dieter, "Mechanical Metallurgy", Third Edition, McGraw - Hill Publications, 1988.

<b>ME103</b>	<b>THEORY OF METAL CUTTING</b>					
<b>(CORE - III)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To emphasize upon the prominent theories, concepts and constructional features of machines related to them.
- To analyze cutting forces, temperature, power and specific energy along the shear and rake Planes
- To introduce various non- traditional machining processes
- To lay groundwork for further studies in manufacturing stream.

**Course Outcomes:** At the end of the course, student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Demonstrate ASA, ORS and NRS systems of tool geometry and derive their interrelationship.	L2
CO2	Develop the relations for chip reduction coefficient, shear angle, shear strain, forces, power, specific energy and temperatures associated with orthogonal cutting.	L3
CO3	Select cutting fluids, cutting tool materials and tool geometry for improving machinability and tool life	L4
CO4	Select unconventional machining processes for machining a given material and required part accuracies.	L3
CO5	Select modern machining processes for machining a given material and required part accuracies	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1	1	3	3	
<b>CO2</b>	2		3	3	
<b>CO3</b>	2		3	3	1
<b>CO4</b>	1		3	3	1
<b>CO5</b>	1		3	3	2

## **UNIT I**

**Geometry of Cutting Tools:** Geometry of single-point cutting tool: Tool-in hand system, ASA, ORS, and NRS system, Conversions between ASA and ORS systems – Graphical Method, Normal Rake System (NRS) & relation with ORS.

**Mechanics of Machining Processes:** Orthogonal cutting, Mechanics of Chip formation: Types of chips, chip-breakers, Chip reduction coefficient, shear angle, shear strain, Built-Up-Edge and its effect in metal cutting, Merchant's analysis of metal cutting process - Various forces, power and specific energy in cutting, Problems on Tool Geometry and Mechanics of Machining, Theories of Metal Cutting: Ernst & Merchant, theory, Modified Merchant's theory, Lee & Shaffer Theory. Stress distribution at Chip-Tool Interface –Machining with controlled contact cutting, Chip breakers.

## **UNIT II**

**Thermal aspects in machining:** Sources of heat generation, Effects of temperature, Determination of cutting temperature using analytical methods, Determination of cutting temperature using experimental methods, Methods of Controlling Cutting Temperature, Cutting Fluids: Functions, characteristics and types, selection of cutting fluids, Tool wear, Tool life, **Machinability and Machining Economics:** Wear Mechanisms, Types of tool wear, Tool Life and Machinability, Problems on Economics of Machining, Cutting Tool Materials:

## **UNIT III**

**Mechanics of Multipoint Machining processes:** Drill geometry & Mechanics of drilling process, Geometry of milling cutters and Mechanics of milling process, Mechanics of grinding (plunge grinding and surface grinding), Grinding wheel wear.

## **UNIT IV**

**Material Removal Mechanism of Advanced Machining Processes:**

Need for non-traditional machining processes. Processes selection, classification, and comparative study of different processes. Mechanical Process: **Ultrasonic Machining**-Definition-Mechanism of metal elements of the process- Tool feed mechanism. Theories of mechanics of causing effect of parameter applications. **Abrasive Jet Machining:** Principles - parameters of the process, applications, advantages and disadvantages. **Water Jet Machining (WJM):** Schematic diagram, equipment used, advantages, disadvantages and applications. **Abrasive Water Jet Machining (AWJM):** Schematic sketch, equipment and abrasives used, advantages, disadvantages and applications. **Thermal Metal Removal Process:** Electric discharge machining Principle and operation – mechanism of metal removal, basic EDM circuitry-spark erosion. Dielectric fluids- flushing-Electrodes, surface finish. Applications. **Wire EDM** principle and operation. Wire materials, wire tension and its parameters. Applications.

## **UNIT V**

**Electro Chemical and Chemical Processes:** Electro chemical machining (ECM) Classification ECM process-principle of ECM Chemistry of the ECM parameters of the processes-determination of the metal removal rate. Tool Design-advantages and disadvantages

- applications. Electro Chemical Grinding - Electro Chemical honing, electrochemical deburring.

**Electron Beam Machining (EBM):** Introduction-Equipment for production of Electron beam - Theory of electron beam machining, Thermal & Non thermal type's characteristics – applications. **Laser Beam Machining (LBM):** Introduction-principle of generation of lasers equipment and machining procedure-types of Lasers-process characteristics-advantages and limitations-applications. **Plasma Arc Machining (PAM):** Introduction-Plasma-generation of Plasma and equipment, mechanism of metals removal, PAN parameters-process characteristics - type of torches, applications.

**Suggested Readings:**

1. David A. Stephenson, John S. Agapiou, Metal Cutting Theory and Practice, CRC Press, 3<sup>rd</sup> Edition, March 2016.
2. M.C. Shaw, Metal cutting principles, First Edition, CBS Publishers and distributors., New Delhi, 2002
3. Bhatta Charya, Metal Cutting Theory and Practice, Central book publishers, Calcutta, 2012.
4. Bhattacharya, New Technology- Institution of Engineers, First Edition, India, 1973.
5. Adithan, Modern Manufacturing Method, 1<sup>st</sup> Edition, New Age International (p) Limited, 1996.
6. P.K. Mishra, Non-Conventional Machining, 1<sup>st</sup> Edition, Narosa Publishing House, New Delhi, 1997.
7. J.A. McGeough, Advanced Methods of Machining, First Edition, Springer, New Delhi-2011.

<b>ME111</b>	<b>FLEXIBLE MANUFACTURING SYSTEMS</b>					
<b>(Program Elective-I)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To learn the evolution of flexible manufacturing systems, layouts human resources involvement.
- To know the manufacturing driving force, design scheduling of jobs, classification and coding technique.
- To understand the working of automated movement, storage systems, tool management, fault detection and relationship with workstations.

**Course Outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Classify and distinguish FMS layouts and planning preparation for FMS	L2
CO2	Identify design, manufacturing attributes and human resources involvement	L2
CO3	Explain processing stations and material handling systems used in FMS environments	L3
CO4	Analyze tool management in FMS	L4
CO5	Evaluate the relationship with FMS workstations and networks	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1	1	1	2	1
<b>CO2</b>	2	2	2	1	2
<b>CO3</b>	2	2	2	2	3
<b>CO4</b>	1	3	3	2	2
<b>CO 5</b>	1	2	2	2	2



### **UNIT - I**

Evolution of Manufacturing Systems: FMS definition and description, General FMS considerations, Manufacturing cells, Cellular versus Flexible Manufacturing. Systems Planning: Objective, introduction planning, preparation guidelines, the project team, supplier selection, system description and sizing, facility preparation planning, FMS layouts, Just in-time manufacturing, Benefits and relationship to FMS, quality and quantity application principles.

### **UNIT - II**

**Group Technology:** Concepts, classification, coding, Reasons for Adopting Group Technology, Production Flow Analysis, Benefits and relationship to FMS, Problems in Group Technology, Quantitative Analysis in Cellular Manufacturing, **Human Resources:** staff considerations, team work, communication and involvement, the supervisor's role, personnel selection, job classifications, employee training.

### **UNIT - III**

**Automated Material Movement and Storage Systems:** AGVs, Robots. Automated Storage and retrieval Systems, Conveyers and pallet floatation systems, queuing Carrousel and automatic work changes, Coolant and chip disposal and recovery systems, Cleaning and Deburring, Wash station types and operation description, Deburring station types and operation description, Importance to Automated Manufacturing, Coordinate measuring machines & types of CMM.

### **UNIT - IV**

**Cutting Tools and Tool Management:** Introduction, getting control of cutting tools, Tool Management, tool strategies, data transfer, tool monitoring and fault detection, Experimental Setup and Data Collection, Work holding considerations, Fixture support and location principles, Fixture considerations in an FMS environment.

### **UNIT - V**

**FMS Networks:** computer Hardware, Software, Communications networks, FMS implementation, hardware configuration, programmable logic controllers, cell controllers, general phases of simulation, reasons to integrate FMS computer system to a central host computer, maintenance concerns.

### **Suggested Reading:**

1. Groover, M.P., "Automation, Production Systems and CIM", Third Edition, Prentice Hall India, 2012.
2. Parrish, D.J, "Flexible Manufacturing", New Edition, Butter Worths, Heinemann, Oxford, 1993
3. H.K. Shivanand, M.M. Benal and V. Koti, "Flexible Manufacturing System", First Edition, New Age International (P) Ltd., 2006.
4. Kusiak, A, "Intelligent Manufacturing Systems", First Edition, Prentice Hall, 1990
5. William W. Luggen., "Flexible Manufacturing Cells and Systems", First Edition, Prentice Hall, Englewood, 1991.
- 6.

<b>ME112</b>	<b>COMPUTER INTEGRATED MANUFACTURING</b>					
<b>(Program Elective-I)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To familiarize students the fundamental concepts of CIM and the Importance of Concurrent engineering
- To understand the role of database management systems, concepts like CAPP, MRP, Cellular manufacturing, FMS and various networking technologies in the successful implementation of CIM.
- To learn the concepts of Lean, Agile, Web based Manufacturing systems and their role in a CIM environment.

**Course outcomes:** After completion of the course student will be able to:

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Interpret the meaning and scope of CIM	L2
CO2	Apply the knowledge of Database Management System in writing SQL Statements for creating and manipulating manufacturing databases	L3
CO3	Illustrate the working of CAPP, MRP, FMS and Solve problems on cell formation approaches and lot sizing techniques	L3
CO4	Select various types of network technologies that will help in establishing Enterprise-wide integration	L4
CO5	Illustrate the working of Lean, Agile and Web Based Manufacturing systems	L3

**Programme Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1		1	2	2
<b>CO2</b>	1		1	2	2
<b>CO3</b>	2	1	2	3	1
<b>CO4</b>	2	1	1	3	2
<b>CO 5</b>	1	1	2	2	2

**UNIT – I: Introduction to CIM**

The meaning of Manufacturing, Types of Manufacturing; Basic Concepts of CIM: CIM Definition, Elements of CIM, CIM wheel, concept or technology, Evolution of CIM, Benefits of CIM, Needs of CIM: Hardware and software. Concurrent Engineering: Definition,

Sequential Engineering Versus Concurrent Engineering, Benefits of Concurrent Engineering, Characteristics of concurrent Engineering, Framework for integration of Life-cycle phases in CE, Concurrent Engineering Techniques, Product Life-Cycle Management (PLM).

**UNIT – II: CIM database and database management systems**

Introduction, Manufacturing Data: Types, sources; Database Terminology, Database requirements, Database models, Database Management System, DBMS Architecture, Query Language, Structural Query Language (SQL): Basic structure, Data definition Language (Create, Alter, Drop, Truncate, View), Data Manipulation Language (store, retrieve, update, delete). Illustration of Creating and Manipulating a Manufacturing Database. SQL as a Knowledge Base Query Language. Features of commercial DBMS: Oracle, MySQL, SQL Access, Sybase, DB2. Product Data Management (PDM), Advantages of PDM.

**UNIT – III: CIM Technology and Systems**

Computer-Aided Process Planning: Basic Steps in developing a process plan, Variant and Generative Process Planning, Feature Recognition in Computer-Aided Process Planning. Material Requirements Planning (MRP): Lot Sizing Techniques: Lot for Lot (LFL), Fixed Order Quantity (FOQ), Periodic Order Quantity (POQ), Economic Order Quantity (EOQ), Fixed Period Requirement (FPR). Manufacturing Resource Planning (MRP –II). Cellular Manufacturing: Design of Cellular Manufacturing Systems, Cell Formation Approaches: Machine–Component Group Analysis, Similarity Coefficients-Based Approaches. Evaluation of Cell Design. Flexible Manufacturing Systems: Physical Components of an FMS, Types of FMS layouts, Operational Problems of FMS. FMS benefits.

**UNIT –IV: Enterprise Wide Integration in CIM**

Introduction to Networking, Principles of Networking, Network Terminology, Types of Networks: LAN, MAN, WAN; Selection of Network Technology: Communication medium, Network Topology, Medium access control Methods, Signaling methods; Network Architectures and Protocols: OSI Model.

**UNIT – V: Future Trends in Manufacturing Systems**

Lean Manufacturing: Definition, Principles of Lean Manufacturing, Characteristics of Lean Manufacturing, Value of Product, Continuous Improvement, Focus on Waste, Relationship of Waste to Profit, Four Functions of Lean Production, Performance Measures, The Supply Chain, Benefits of Lean Manufacturing. Introduction to Agile and Web Based Manufacturing systems.

**Suggested Readings:**

1. S. Kant Vajpayee, Computer integrated manufacturing, 1<sup>st</sup> Edition, Prentice Hall of India, 1998
2. Nanua Singh, System Approach to Computer Integrated Manufacturing, Volume 28, Wiley and sons Inc, 1996.
3. P. Radhakrishnan, S. Subramanyam: CAD/CAM/CIM, 1<sup>st</sup> Edition, New Age International, 2007.
4. Alavudeen, Venkateshwaran: Computer Integrated Manufacturing, 1<sup>st</sup> Edition, Printice-HallIndia, 2010.

<b>(Program Elective-I)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To learn the concepts and principles of manufacturing automation
- To understand the components of automation and their practical use in manufacturing application
- Learn principles of assembly systems and material handling systems.
- Understand quality control and other support systems used in automated system
- To provide information integration and data warehousing

**Course Outcomes: At the end of the course, student will be able to**

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Understand the concepts and the effect of manufacturing automation strategies	L1
CO2	Apply the principles of automation	L3
CO3	Design automated material handling and storage systems	L4
CO4	Analyze automated flow lines and assembly systems, and balance the line.	L3
CO5	Make use of automated inspection methods	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	2	1	2	--
<b>CO2</b>	3	2	1	1	--
<b>CO3</b>	3	3	1	2	--
<b>CO4</b>	3	3	2	2	--
<b>CO 5</b>	3	3	2	2	--

**UNIT – I**

**Introduction:** Definition of automation, Types of production, Functions of Manufacturing, Organization and Information Processing in Manufacturing, Production concepts and Mathematical Models, Automation Strategies, Production Economics: Costs in Manufacturing, Break-Even Analysis, Unit cost of production, Cost of Manufacturing Lead time and Work-in-process.

## **UNIT – II**

**Automation Production Lines:** Automated Flow lines, Methods of Work part Transport, Transfer Mechanism, Buffer Storage, Control Functions, Automation for Machining Operations, Design and Fabrication Considerations. Analysis of Automated Flow Lines: General Terminology and Analysis, Analysis of Transfer Lines Without Storage, Partial Automation, Automated Flow Lines with Storage Buffers, Simulation of Automated Flow Lines.

## **UNIT – III**

**Assembly Systems and Line Balancing:** The Assembly Process, Assembly Systems, Manual Assembly Lines, Methods of Line Balancing, Other ways to improve the Line Balancing, The Line Balancing Problem, Flexible Manual Assembly Lines. Automated Assembly Systems: Design for Automated Assembly, Types of Automated Assembly Systems, Part Feeding Devices, Analysis of Multi-station Assembly Machines, Analysis of a Single Station Assembly Machine.

## **UNIT –IV**

**Automated Materials Handling:** The material handling function, Types of Material Handling Equipment, Analysis for Material Handling Systems, Design of the System, Conveyor Systems, Automated Guided Vehicle Systems. Automated Storage Systems: Storage System Performance, Automated Storage/Retrieval Systems, Carousel Storage Systems, Work-in-process Storage, Interfacing Handling and Storage with Manufacturing.

## **UNIT – V**

**Automated Inspection and Testing:** Inspection and testing, Statistical Quality Control, Automated Inspection Principles and Methods, Sensor Technologies for Automated Inspection, Coordinate Measuring Machines, Other Contact Inspection Methods, Machine Vision, Other optical Inspection Methods. The Future Automated Factory: Trends in Manufacturing, The Future Automated Factory, Human workers in the Future Automated Factory and the social impact.

### **Suggested Reading:**

1. Mikell P.Grover, “Automation, Production Systems and Computer Integrated Manufacturing”, Fourth Edition, Pearson Education Asia, 2016.
2. C.Ray Asfahl, “Robots and manufacturing Automation”, Second Edition, John Wiley and Sons New York, 1992.
3. N.Viswanadham and Y.Narahari, “Performance Modeling of Automated Manufacturing Systems”, First Edition, Printice Hall India Pvt. Ltd, 1992.
4. Stephen J. Derby, Design of Automatic Machinery, Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai 2004.

<b>ME114</b>	<b>MANUFACTURING MANAGEMENT</b>					
<b>(Program Elective-I)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To know the history of manufacturing and the importance of recent challenges in Manufacturing.
- To understand the working of Enterprise Resource Planning and importance of Human Factors Engineering, Just in Time and Total Productive Maintenance (TPM) in the functioning of an Enterprise
- To study the various manufacturing strategies and modern methods of manufacturing performance.

**Course outcomes:** After completion of the course student will be able to:

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Interpret the history of manufacturing and recent challenges in manufacturing	L2
CO2	Identify Enterprise Resource Planning as a new manufacturing management tool.	L2
CO3	Recognize the role of Human Factors Engineering in the effective management of a manufacturing enterprise	L1
CO4	Summarize the role of JIT, TPM and purchasing function in effective running of an enterprise.	L2
CO5	Analyze the modern methods of measuring manufacturing performance	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	2	1	1	
<b>CO2</b>	2	2	3	1	1
<b>CO3</b>	3	2	1	1	
<b>CO4</b>	2	2	1	1	
<b>CO 5</b>	3	1	3	1	1

### **UNIT-I**

**Introduction to Manufacturing:** History of manufacturing, Selection of manufacturing processes, CIM, Global competitiveness and manufacturing costs, Environmental consciousness in Manufacturing. Terms and Definitions used in materials handling, Principles of material handling equipments, Factors in selection of Materials handling system.

### **UNIT-II**

**Enterprise Resource Planning:** An Overview Integrated Management Information, Business Modeling, Integrated Data Model, Benefits of ERP, ERP and Related Technologies, Various ERP Modules, Features of ERP Software like SAP AG, PeopleSoft, Baan, JD Edwards, Oracle. ERP and E-Commerce, ERP and Internet.

### **UNIT-III**

**Human Factors Engineering:** Introduction, Focus of Ergonomics, Basic Work system, History of Ergonomics, Human performance Psychology, Fit the Man to the Job (FMJ), fitting the Job to the Man (FJM), Man-Machine Interface, human body measurement – layout of equipment – seat design - design of controls and compatibility – environmental control – vision and design of displays, design of work space, Anthropometry. Case Studies.

### **UNIT-IV**

**JIT Approach:** Just In Time (JIT), JIT in repetitive production environments, batch manufacturing environment, JIT-Production Control – the KANBAN System, Benefits of JIT. Total Productive Maintenance (TPM), TPM and JIT.

**Purchasing and Physical Distribution:** Purchasing Function, Supplier Management and monitoring, Purchasing methods, Distribution and logistics, Distribution strategy.

### **UNIT-V**

**Manufacturing Strategy:** Strategic Business units, the strategy document, Generic Strategies. Manufacturing Performance Measurement, Performance Monitoring, Accounting based methods of measuring manufacturing performance, Modern Methods of Measuring Manufacturing Performance.

### **Suggested Readings:**

1. Serope Kalpakjain and Steven R. Schmid, Manufacturing Engineering and Technology, 4<sup>th</sup> Edition, Pearson Education Inc., 2013.
2. Peter Gibson, R. Kerr, “Manufacturing Management: Principles and Concepts”, Springer; 1995 edition.
3. S.Sadagopan, ERP: A managerial Perspective, 1<sup>st</sup> Edition, Tata McGraw-Hill publishing company Limited, 1999.
4. Kanishka Bedi, Production and Operations Management, Oxford University Press, 3<sup>rd</sup> Edition, 2013.

<b>(Program Elective-I)</b>							
<b>Pre-requisites</b>				<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
				3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks		

**Course Objectives:**

- To know the Main concepts and components of Industry 4.0
- To understand the role of data analytics, Internet of Things (IoT), robotics and augmented reality in the implementation of Industry 4.0
- To learn the working of various Additive Manufacturing (AM) Technologies, Virtual Factory and role of Cyber security in the successful implementation of Industry 4.0

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Interpret the meaning and scope of Industry 4.0	L2
CO2	Illustrate the role of Data Analytics and IoT in a Manufacturing Industry	L2
CO3	Recognise the role of Robotics and Augmented Reality in the implementation of Industry 4.0	L3
CO4	Identify the role of Additive Manufacturing Technology in Industry 4.0 and interpret the working of various AM technologies and their applications	L3
CO5	Analyse the role of virtual factory, digital traceability and Cyber Security in the implementation of Industry 4.0	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	2	1	1	
<b>CO2</b>	3	1	2	3	
<b>CO3</b>	2	2	3	3	
<b>CO4</b>	3	1	2	3	
<b>CO 5</b>	2	1	3	2	

**UNIT – I: Introduction**

Definition, Main concepts and components of Industry 4.0, Proposed Framework of Industry 4.0, Smart and Connected Product Business Models, Smart Manufacturing, Lean Production Systems for Industry 4.0, The changing role of Engineering Education in Industry 4.0 Era, Industry 4.0 laboratories, Opportunities and Challenges of Industry 4.0, Future Skills required by Workers in the Industry 4.0 Era, Strategies for competing in an Industry 4.0 world.



**UNIT – II: Data Analytics and Internet of Things in Manufacturing**

Introduction to data analytics, Techniques used for Predictive Analytics, Forecast Accuracy Calculations, A real world Case Study; Introduction to IoT, Examples for IoTs Value Creation in Different Industries. IoTs Value Creation Barriers: Standards, Security and Privacy Concerns.

**UNIT – III: Robotics and Augmented Reality in Industry 4.0**

Introduction, Recent Technological Components of Robots: Advanced Sensor Technologies, Artificial Intelligence, Internet of Robot Things, Cloud Robotics, Cognitive Architecture for Cyber-Physical Robotics, Industrial Robotic Applications. Introduction to Augmented Reality: Augmented Reality Hardware and Software Technology, Industrial Applications of Augmented Reality

**UNIT – IV: Additive Manufacturing Technologies and Applications**

Introduction, Additive Manufacturing (AM) Technologies: Stereolithography, 3DP, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, Laser Engineered Net shaping, Advantages and Disadvantages of Additive Manufacturing. Applications of Additive Manufacturing in Medical, Surgical Planning, Implant and Tissue Design, Automotive, Aerospace, Electronics, Education and Oceanography. Impact of AM Technologies on society: Impact on health care, Environment, Manufacturing and Supply Chain.

**UNIT – V: Virtual Factory, Digital Traceability and Cyber Security**

Introduction to Virtual Factory, Virtual Factory Software, Limitations of Commercial Software; Introduction to Digital Traceability, Digital Traceability Technologies, Architectural Framework, Applications, Project Management in Digital Traceability; Introduction to Cyber Security, Security Threats and Vulnerabilities of IoT, Industrial Challenges, Evolution of Cyber Attacks, Cases on Cyber Attacks and Solutions, Strategic Principles in Cyber Security, Cyber Security Measures.

**Suggested Readings:**

1. Alp Ustundag and Emre Cevikcan, “Industry 4.0: Managing the Digital Transformation” 1<sup>st</sup>Edition, Springer Series, 2018.
2. Alasdair Gilchrist, “Industry 4.0: The Industrial Internet of Things”, 1<sup>st</sup> edition, Apress, 2019.
3. Dr.-Ing. Klaus Schwab, “The fourth Industrial Revolution”, 1<sup>st</sup> edition, Penguin Publisher, 2017.

<b>ME116</b>	<b>MECHATRONICS AND INDUSTRIAL ROBOTICS</b>					
<b>(Program Elective-II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:** After completion of the course student will be able to

- Model analyze and control engineering systems
- Select appropriate sensors, transducers and actuators to monitor and control the behavior of a process or product.
- Develop PLC programs for a given task.
- Evaluate the performance of mechatronic systems.
- Understand the evolution, classification, structures and drives for robots.

### Course Outcomes

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
<b>CO1</b>	Learn the mechatronics system components and its construction	L1
<b>CO2</b>	Apply the sensors in designing of mechatronics systems	L2
<b>CO3</b>	Develop the new mechatronics system suitable to situation	L3
<b>CO4</b>	Create the new mechatronics systems for different application	L4
<b>CO5</b>	Explore the new mechatronics system	L5

### Program Articulation Matrix

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1	2	3	3	
<b>CO2</b>	2	3	2	2	2
<b>CO3</b>	1	2	3	3	2
<b>CO4</b>	1	3	1	2	3
<b>CO 5</b>	2	2	3	2	3

### UNIT I

Introduction: Introduction, elements of mechatronic systems, needs and benefits of mechatronics in manufacturing.

**Design of Sensors:** Classification of sensors basic working principles, Displacement Sensor Linear and rotary potentiometers, LVDT and RVDT, incremental and absolute encoders. Strain gauges. Force/Torque – Load cells. Temperature – Thermocouple, Bimetallic Strips, Thermistor, RTD.

**Accelerometers, Velocity sensors** – Tachometers, Proximity and Range sensors – Eddy current sensor, ultrasonic sensor, laser interferometer transducer, Hall Effect sensor, inductive proximity switch. Light sensors – Photodiodes, phototransistors, Flow sensors – Ultrasonic sensor, laser Doppler anemometer tactile sensors – PVDF tactile sensor, micro-switch and reed switch Piezoelectric sensors, vision sensor. Selection of appropriate sensor for real time applications.

## **UNIT II**

**Design of Actuator Circuits:** Electrical Actuators :Solenoids, relays, diodes, thyristors, triacs, BJT, FET, DC motor, Servo motor, BLDC Motor, AC Motor, stepper motors. Hydraulic & Pneumatic devices – Power supplies, valves, cylinder sequencing. Development of Hydraulic & Pneumatic circuits for automation applications. Piezoelectric actuators, Shape memory alloys.

**Basic System Models & Analysis:** Modelling of one and two degrees of freedom mechanical, Electrical, Fluid and thermal systems, Block diagram representations for these systems. Dynamic Responses of System: Transfer function, Modelling Dynamic systems, first order systems, second order systems.

## **UNIT III**

**Digital Electronics:** Number systems, BCD codes and arithmetic, Gray codes, self-complementing codes, Error detection and correction principles. Boolean functions using Karnaugh map, Design of combinational circuits, Design of arithmetic circuits. Design of Code converters, Encoders and decoders.

**Signal Conditioning:** Operational amplifiers, inverting amplifier, differential amplifier, Protection, comparator, filters, Multiplexer, Pulse width Modulation Counters, decoders. Data acquisition – Quantizing theory, Analog to digital conversion, digital to analog conversion.

## **UNIT IV**

**Controllers:** Classification of control systems, Feedback, closed loop and open loop systems, Continuous and discrete processes, control modes, Two step Proportional, Derivative, Integral, PID controllers.

**PLC Programming:** PLC Principles of operation PLC sizes PLC hardware components I/O section Analog I/O section Analog I/O modules, digital I/O modules CPU Processor memory module Programming. Ladder Programming, ladder diagrams, timers, internal relays and counters, data handling, analogue input and output. Application on real time industrial automation systems.

## **UNIT V**

**Case studies of Mechatronics systems:** Pick and place robot, Bar code, Engine Management system, Washing machine etc.

**Robotics:** Introduction to Robotics, Robot anatomy physical configurations, Manipulator, Kinematics and dynamics, Technical features of Industrial robots.

**Suggested Reading:**

1. W. Bolton, "Mechatronics", 5<sup>th</sup> edition, Addison Wesley Longman Ltd, 2010
2. DevdasShetty & Richard Kolk "Mechatronics System Design", 3<sup>rd</sup> edition. PWS Publishing, 2009.
3. Alciatore David G & Hstand Michael B, "Introduction to Mechatronics and Measurement systems", 4<sup>th</sup> edition, Tata McGraw Hill, 2006.
4. Saeed B Niku, "Introduction to Robotics: Analysis, Systems, Applications", 2<sup>nd</sup> edition, Pearson Education India, PHI, 2003.

<b>(Program Elective-II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To understand the basic concepts and stress and strain.
- To know stress-strain relationships for isotropic body and plane stress and plane strain conditions
- To learn the difference between True stress and true strain and analysis methods.

**Course outcomes:** After completion of the course student will be able to:

CO's	Description	Blooms Level
CO1	Analyse the problems of 2-D elasticity in Cartesian/Polar Coordinates.	L2
CO2	Analyze the structures using plasticity.	L3
CO3	Demonstrate various theories of torsion of prismatic bars of various cross sections and can solve the problems of torsion.	L3
CO4	Describe the application of plane stress and plane strain in a given situation.	L4
CO5	Able to solve the problems of 3-D elasticity.	L3

**Programme Articulation Matrix**

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
<b>CO1</b>	3	1	2	1	1
<b>CO2</b>	3	2	3	1	
<b>CO3</b>	3	2	3	1	
<b>CO4</b>	1	2	2	1	
<b>CO 5</b>	1	3	1	2	

**UNIT-I**

**Basic Concepts of Stress:** Definition, State of Stress at a point, Stress tensor, invariants of stress tensor, principle stresses, stress ellipsoid, derivation for maximum shear stress and planes of maximum shear stress, octahedral shear stress, Deviatoric and Hydrostatic components of stress, Invariance of Deviatoric stress tensor, plane stress.

**UNIT-II**

**Basic concepts of Strain:** Deformation tensor, Strain tensor and rotation tensor; invariants of strain tensor, principle strains, derivation for maximum shear strain and planes of maximum shear strain, octahedral shear strain, Deviatoric and Hydrostatic components of strain tensor, Invariance of Deviatoric strain tensor, plane strain.

### **UNIT-III**

**Generalized Hooke's Law:** Stress-strain relationships for an isotropic body for three dimensional stress space, for plane stress and plane strain conditions, differential equations of equilibrium, compatibility equations, Material (D) matrix for Orthotropic Materials.

### **UNIT-IV**

**True stress and true strain,** Von-Mises and Tresca yield criteria, Haigh–Westergard stress space representation of von-Mises and Tresca yield criteria, effective stress and effective strain, St. Venants theory of plastic flow, Prandtl–Reuss and Levy–Mises constitutive equations of plastic flow, Strain hardening and work hardening theories, work of plastic deformation.

### **UNIT-V**

**Analysis methods:** Slab method, Slip line field method, uniform deformation energy method, upper and lower bound solutions. Application of Slab method to forging, wire drawing, extrusion and rolling processes.

### **Suggested Readings:**

1. Timoshenko and Goodier, "Theory of Elasticity", McGraw Hill Publications 3rd Edition, 2017.
2. J. Chakrabarty, "Theory of Plasticity", 2nd edition, McGraw Hill Publications, 1998.
3. George E Dieter, "Mechanical Metallurgy", Third Edition, McGraw Hill Publications 2017.

<b>ME118</b>	<b>SURFACE ENGINEERING</b>
<b>(Program Elective-II)</b>	

<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

### Course Objectives

- To learn the physics and concept of surface of engineering
- To explore various methods of methods of surface can be created
- To characterize and validate the surface properties

### Course Outcomes

CO's	Description	Blooms Level
CO1	To Understand properties of surface engineering	L1
CO2	Learn various methods of surfaces can be modified for Engineering	L2
CO3	To apply the surface engineering parts for particular application	L2
CO4	Analyse the surface for engineering service	L4
CO5	Evaluate the engineering surface to different environments	L5

### Program Articulation Matrix

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3	1	2
CO2	2	3	3	1	2
CO3	1	2	2	2	1
CO4	2	2	3	2	2
CO 5	1	2	2	3	3

#### UNIT I

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

#### UNIT II

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

#### UNIT III

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

#### **UNIT IV**

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

#### **UNIT V**

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

#### **Suggested Readings:**

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



<b>(Program Elective-II)</b>							
<b>Pre-requisites</b>				<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
				3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks		<b>CIE</b>		40 Marks	

**Course Objectives:**

- To study various aspects of Quality Engineering to solve problems using Statistical Quality Control & Quality loss function.
- To understand various quality management systems like ISO 9000, TQM etc. and their basic principle of working & implementation techniques.
- To study Reliability Engineering for assessment & improvement of systems reliability using various hazard models.

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Evaluate quality improvement through statistical process control charts and use of acceptance sampling & explain the implications of quality cost	L4
CO2	Solve problems in tolerance design using quality loss function.	L3
CO3	Plan the quality function deployment and understand various quality management systems like ISO 9000, TQM etc. and their basic principle of working	L4
CO4	Calculate reliability using various hazard models. Reliability calculation of systems in series and parallel.	L3
CO5	Explain the concepts of maintainability, availability, maintenance costing and Reliability testing.	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>1</b>
<b>CO2</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>1</b>
<b>CO3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>2</b>
<b>CO4</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>2</b>	
<b>CO 5</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>2</b>	

**Unit-I**

Quality and value engineering, Quality systems – quality engineering in product design and production process – system design – parameter design – tolerance design quality costs –quality improvement. Statistical Process Control- x, R, P, C charts, process capability. Acceptance Sampling by variables and attributes, Design of Sampling Plans, Single, Double, Sequential plans.

**Unit-II**

**Loss Function**, Tolerance Design, N Type, L Type, S Type; determination of tolerance for these types, nonlinear tolerances. Online Quality Control – Variable Characteristics, Attribute Characteristics, Parameter Design.

**Unit-III**

**Quality function deployment**, House of Quality, QFD Matrix, Total Quality Management Concepts. Quality Information Systems; Quality Circles, Introduction to ISO 9000 Standards.

**Unit-IV**

**Reliability**, Evaluation of design by tests - Hazard Models; Linear, Releigh, Weibull. Failure Data Analysis System, Reliability, Reliability of series, Parallel Standey Systems; reliability prediction and system effectiveness, reliability prediction based on weibull distribution, Reliability improvement.

**Unit-V**

**Maintainability, Availability**, Economics of Reliability Engineering; Replacement of items, Maintenance Costing and Budgeting, Reliability Testing – Burn in testing by binomial exponential models, Accelerated life testing.

**Suggested Readings:**

1. G Taguchi, "Quality Engineering in Production Systems", - McGraw Hill, 1989.
2. W.A. Taylor, "Optimization & Variation Reduction in Quality", Tata McGraw Hill, 1991, 1<sup>st</sup> Edition.
3. Philipposs, "Taguchi Techniques for Quality Engineering", McGraw Hill, 1996, 2<sup>nd</sup> Edition.
4. E.Bala Guruswamy, "Reliability Engineering", Tata McGraw Hill, 1994.
5. LS Srinath, "Reliability Engineering", Affiliated East West Pvt. Ltd., 1991, 3<sup>rd</sup> Edition

<b>(Program Elective-II)</b>							
<b>Pre-requisites</b>				<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
				3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks		

**Course Objectives:**

- Learn the Industrial practice of length measurement
- Study the Dimensional of parts manufactured the process
- Study the geometrical forms of parts
- Study the verification geometric configuration

**Course outcomes:** At the end of the course the student will be able to:

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Understand the functioning of slip gauges, micrometer and concept of interchangeability	L3
CO2	Understand the working of Fixed and Indicating gauges	L3
CO3	Know the working of measuring machines	L4
CO4	Identify various types of form errors and their rectification	L3
CO5	Understand the measurement of screw threads and gears	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>3</b>
<b>CO2</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>2</b>	<b>3</b>
<b>CO3</b>	<b>2</b>	<b>2</b>	<b>1</b>	<b>3</b>	<b>3</b>
<b>CO4</b>	<b>1</b>	<b>3</b>	<b>2</b>	<b>2</b>	<b>3</b>
<b>CO 5</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>3</b>

**UNIT-I**

End & line standards for length, Airy & Bessel points, desirable features of end standards, slip gauge manufacture, calibration of end standards by interferometry. NPL gauge interferometer, calibration of line standards by micrometer microscope – superposition, coincidence and symmetric straddling, photoelectric microscope and Moiré fringe techniques, measurement of large displacements using lasers, calibration of Tomlinson gauges by interferometry.

Photoelectric Autocollimator, calibration of polygons & circular scales. Types of interchangeability, dimensional chains.

## **UNIT-II**

**Fixed & Indicating Gauges:** Taylor's principles of gauge design, limitations of ring & plug gauges, position and receiver gauges, types of indicating gauges. **Comparators:** Multirange Sigma comparator, Back pressure and free flow type pneumatic comparators, Differential back pressure gauge, usage of different types of jets, contact & non contact tooling. Amplification selection. Air to electric transducer, Differential transducer, Variation transducer, Pre process, In-process & Post process gauging, computation & match gauging. Usage of LVDT & Capacitive type gauge heads, Automatic inspection.

## **UNIT-III**

**Measuring Machines:** Floating carriage diameter measuring m/c. Universal measuring m/c. Matrix internal diameter measuring machine. Optical dividing head. Coordinate measuring machine, Optical projector-light beam systems, Work tables, measurement techniques, fixturing & accessories. Sources of error in measurement. Design principles of measuring machines Abbe's rule, Kelvin coupling, flexible steel strip, advantages & limitations of hydrostatic & aerostatic bearings.

## **UNIT-IV**

**Form Errors:** Evaluation of straightness & flatness, usage of beam comparator, evaluation of roundness – intrinsic & extrinsic datum's. Talyrond. PGC, RGC, MZC & LSC, methods, roundness evaluation for even & odd number of lobes. Surface Finish: stylus instrument (TALYSURF). M & E Systems, numerical assessment, vertical & horizontal descriptors, profile as a random process, usage of interferograms. Plastic replica technique.

## **UNIT-V**

**Screw Threads:** Measurement of thread elements for internal & external threads, progressive periodic, drunkenness and irregular pitch errors. NPL pitch measuring machine, virtual effective diameter, thread gauging. Gears: measurement of tooth thickness, involute profile, pitch, concentricity and alignment, rolling gear test.

### **Suggested Reading:**

1. R.K.Jain, "Engineering Metrology", 21<sup>st</sup> Edition, Khanna Publishers, 1984.
2. ASTM, "Hand Book of Industrial Metrology", First Edition, Prentice Hall of India Pvt Ltd, 1967.
3. I.C. Gupta, "A Textbook of Engineering Metrology", First Edition, Dhanpat Rai & Sons, 1899.

ME121	<b>TOOL ENGINEERING</b>					
<b>(Program Elective-III)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- Understand the geometry and manufacturing of single point cutting tools, form tools and multi point cutting tools.
- To study the design of press tools and Jigs and fixtures for a given component
- To acquire knowledge in tooling for automats, economics of tooling and gauge design

**Course Outcomes:** After completion of the course student will be able to

CO's	Description	Blooms Level
C01	Acquire knowledge in single point cutting tools, form tools.	L2
C02	Interpret the design and manufacturing of multi point cutting tool to machine a required job.	L2
C03	Design a die and punch for blanking, piercing, drawing and bending operations.	L5
C04	Design a location and clamping system for a given component.	L4
C05	Design of gauge to measure a given component and acquire knowledge in forging die design and economics of tooling	L3

**Program Articulation Matrix**

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	1		1	1	
CO2	2		2	3	
CO3	2	1	3	3	2
CO4	2	1	3	3	2
CO5	2		1	2	1

**UNIT-I**

**Design of single-point cutting tools:** Tool strength and rigidity calculation, selection of tool angles, chip breakers, carbide, tipped tools. Manufacturing of single point cutting tool. **Form**

**Tools:** Types of form tools, method of determining the profile of circular and flat form of tool, analytical and graphical method. Cutting principle by form generation gear shapers & hobs.

#### **UNIT-II**

**Design of Multi Point Cutting tools:** Geometry, types and design of Twist drills, Reamers, Milling cutters, broaches.

**Manufacturing of Multi Point Cutting Tools:** Manufacturing of Twist drills, Reamers, Milling cutters, broaches.

#### **UNIT-III**

**Design of Press Tools:** blanking, piercing, bending and drawing operations, center of pressure clearances, strip layout, punch force, blank size, number of draws, single, compound and progressive press tools. Drawing dies, Deep Drawing of Cups, Blank diameter, Drawing force Design of bending die.

#### **UNIT-IV**

**Design of Jigs and Fixtures:** Principles of location and clamping, locating and clamping elements and their standardization, Diamond pin, Redundant location, fool proofing, classification of Drill Jigs, Drill bushings and liners. Quick clamping devices. Designing jig and fixture. Design principles of Drilling Jigs, Milling fixtures, welding fixtures, fixturing of NC machines.

#### **UNIT-V**

**Forging Die Design:** Allowances, Forging process, Forging die design, Drop forging Dies and auxiliary tools, Upset forging.

**Gauge design:** Gauge principles, types, gauge allowances and tolerance, materials for gauges.

**Economics of Tooling:** Economics if small tool selection, Breakeven point analysis, Economic lot size, Tooling for Automats: Cam design for automats,

#### **Suggested Reading:**

1. ASTME, Fundamentals of Tool Design.
2. P.C.Sharma, A textbook of Production Engineering, 8<sup>th</sup> Edition, S Chand, 1999.
3. G.R. Nagpal, Tool Engineering and Design. 1st Edition, Khanna Publication, 2000.
4. P.H.Joshi, Press Tools Design And Construction, First edition ,S Chand, 2017
5. John G. Nee, Fundamentals of Tool Design, Sixth Edition, Society of Manufacturing Engineers 2010.
6. P.H.Joshi, Jigs and Fixtures, third edition, Tata McGraw-Hill Education, 2017.
7. K. Venkataraman, Design of Jigs, Fixtures and Press Tools, John Wiley & Sons Ltd. Athena Academic, 2015.

<b>(Programme Elective-III)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- Redesign of Manufacturing Processes in producing parts utilizing various Raw materials, appropriate tolerances combination for most convenient manufacturing without compromising the Quality.
- Understand use of metallic, non-metallic, welded, assembled components design involving various forming and machining processes with their capabilities and limitations.
- Understand achieving overall economics due to implementation of positive impact of Assembled part modifications and latest techniques. Make case studies to identify opportunities for economic design and redesign for manufacture.

**Course Outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Evaluate and suggest/use of appropriate tolerances with suitable economic raw material for the parts design.	L4
CO2	Plan the use of metallic components design involving various metal forming and basic machining processes with their capabilities and limitations	L4
CO3	Plan the utilization of metallic components design for planned shaped, centre less ground, EDM, roll finished,, Electrochemical and advanced machine parts.	L4
CO4	Calculate the economics of using non-metallic component design made with various plastics and ceramics. Assembled and welded parts.	L4
CO5	Explain the overall economics using, Low Cost Automation, GT& FMS, Assembled Part Modifications. Make case studies to identify opportunities for economic design and redesign for manufacture	L3

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	<b>2</b>	<b>3</b>	<b>2</b>	<b>3</b>	
<b>CO2</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>3</b>	
<b>CO3</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>1</b>	
<b>CO4</b>	<b>2</b>	<b>3</b>	<b>1</b>	<b>3</b>	
<b>CO 5</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>2</b>

**UNIT – I: Introduction**

General design principles for manufacturability, strength and mechanical factors, mechanisms selection, evaluation method, geometrical tolerances, tolerance control and utilization. Economic Use of Raw Materials: Ferrous steel, hot rolled steel, cold finished steel, stainless steel, non ferrous materials aluminium, copper, brass, non metallic materials, plastics, rubber and composites.

**UNIT – II: Metallic Components Design**

Metal extrusion, metal stamping, fine blanking, four slide parts, spring and wire forms, spun metal parts, cold headed parts, extruded parts, tube and section bends, rolled formed parts, power metal parts, forging electro forming parts, specialized forming methods, turned parts, machined round holes, drilled parts, milled parts.

**UNIT-III: Metallic Components Design**

Planned shaped and slotted parts, screw threaded contoured and internal ground parts, center less ground, electrical discharged, rolled furnished parts, electro chemical and advanced machine parts. Sand cast, die cast, investment cast and other cast products.

**UNIT-IV: Non Metallic Components Design**

Thermosetting plastic, injection moulded and rotational moulded parts, blow moulded, welded plastic articles, ceramics. Assembled Parts Design: Welded parts, arc, resistance, brazed and soldered parts, gear box assembly, bearing assembly.

**UNIT-V: Assembled Parts Design**

Retension, bolted connection, screwed connections, flanged connections, centred connections, press fitted connections, surface finishing, plated parts, heat treated parts, NC machining, group technology, low cost automation, computer aided manufacture, product design requirements.

**Case Studies:** Identification of economical design and redesign for manufacture.

**Suggested Readings:**

1. James G. Bralla, “Hand book of product design for manufacturing”, First Edition, McGraw Hill Co., 1986
2. K.G. Swift, “Knowledge based design for Manufacture”, First Edition, Kogan page Limited, 1987.

<b>ME123</b>	<b>TRIBOLOGY</b>
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<b>(Program Elective-III)</b>							
<b>Pre-requisites</b>				<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
				3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks		<b>CIE</b>		40 Marks	

### Course Objectives

- Learn basic understand of surface of metals
- Understand the classification of surfaces
- Learn wear mechanism methods
- Learn methods to reduce friction between mating surfaces
- Learn to measure surface using equipment

### Course Outcomes

CO's	Description	Blooms Level
CO1	Learn basic concept and types of metallic surface	L1
CO2	Understand the classification of surfaces	L2
CO3	Analyse the types of wear mechanism	L3
CO4	Suggest methods of wear on surfaces	L4
CO5	Design the functional surface for application	L5

### Program Articulation Matrix

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	1	2	3		
CO2	1	2	3	4	
CO3	1	2	3		
CO4	1	2	3	4	
CO 5	1	2	3		

### UNIT I

**Industrial significance of tribology**– Strength and deformation properties of solids – physio-chemical characteristics of solid surfaces –fracture-modes of fracture- ductile-brittle-Analysis of surface roughness – measurement.

### UNIT II

**Friction** – classification – Adhesion theory of friction – Elastic, plastic and visco– elastic effects in friction – rolling friction – friction of materials – alloys – ceramics – polymers – Interface temperature of sliding surfaces – measurement.

### UNIT III

**Wear**– forms of wear-abrasive wear –adhesive wear-erosive wear-cavitation wear-corrosive wear-oxidative wear-fatigue wear-melting wear-diffusive wear-mechanisms-wear of non-metallic materials.

#### **UNIT IV**

**Lubrication** –types of lubrication-hydro dynamic lubrication – Reynolds equation – hydrostatic lubrication– bearing analysis –elasto-hydrodynamic lubrication – solid lubrication – boundary lubrication.

#### **UNIT V**

**Micro/nanotribology** – Measurement techniques – Surface Force Apparatus (SFA) – Scanning Probe Microscopy – Atomic Force Microscopy (AFM)-Nano-mechanical Properties of Solid Surfaces and Thin Films – Computer Simulations of Nanometer-Scale Indentation and Friction.

#### **Suggested Reading:**

1. I.M. Hutchings, “Tribology: Friction and Wear of Engineering Materials”, 2<sup>nd</sup> Edition, Elsevier Limited, 2007.
2. G. W. Stachowiak, A. W. Batchelor, “Engineering Tribology”, 3<sup>rd</sup> Edition, Elsevier Limited, 2005.
3. K.C.Ludema, “Friction, wear, lubrication: A text book in tribology”, 1<sup>st</sup> Edition, CRC Press, 1996.
4. Bharat Bhushan, “Principles and applications of tribology”, 1<sup>st</sup> Edition, John Wiley & Sons, 1999.
5. Bharat Bhushan, “Nanotribology and Nanomechanics: An Introduction”, 2<sup>nd</sup> Edition, Springer, 2008.

<b>(Program Elective-III)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

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

- 1 To understand basic processes of physical phenomenon in industrial use
- 2 To learn various methods of modeling the process on scientific basis for linear and nonlinear
- 3 To solve for the unconstrained optimization of single and multi variables of the processes
- 4 To learn to solve the process by fraction or integer numbers for optimization
- 5 To solve by heuristic methods for optimization of the process

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Understand the basic modeling of the industrial processes	II
CO2	Identify the mathematical modeling through simulation	III
CO3	Analyse the simulation models with unbounded conditions	IV
CO4	Apply the un bounded models to multi objective purposes	II
CO5	Formulate the model for a given situation/s	II

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	2	2	1	2	1
<b>CO2</b>	2	2	2	2	1
<b>CO3</b>	2	2	1	2	1
<b>CO4</b>	2	2	1	2	1
<b>CO 5</b>	2	2	2	2	1

**UNIT-I**

**Simulation:** Introduction, Types of Simulation, Simulation Models, Monte Carlo Simulation, Random Number, Pseudo Random Number, Mid-Square Method of generating Random Numbers, Application & Limitation, Application of Simulation to Inventory Control and Queuing Problem

## **UNIT-II**

**Classical Optimization:** Introduction; Unconstrained problems of maxima and minima, constrained problems of maxima and minima; Constraints in the form of equations – Lagrangian method; Constraints in the form of inequalities -Kuhn-tucker conditions

## **UNIT-III**

**Single Variable Non-Linear Unconstrained Optimization:** Elimination methods: UniModel function-its importance, Fibonacci method & Golden section method. Interpolation methods: Quadratic & Cubic interpolation methods.

## **UNIT-IV**

**Multi variable non-linear unconstrained optimization:** Direct search methods–Univariate method, Pattern search methods –Powell’s, Hook -Jeeves, Rosenbrock search methods. Gradient methods: Gradient of function& its importance, Steepest descent method, Conjugate direction methods: Fletcher-Reeves method & variable metric method.

## **UNIT-V**

**Integer Programming:** Introduction, Types of Integer Programming Problems, Gomory’s Cutting Plane method. Branch and Bound method for all Integer Programming Problems & Mixed Integer Programming Problems. Stochastic Programming: Basic concepts of probability theory, random variables distributions-mean, variance, correlation, co variance, joint probability distribution. Stochastic linear programming: Chance constrained algorithm.

### **Suggested Readings:**

1. Montgomery, D.C., Design and Analysis of experiments, John Wiley and Sons, 2003.
2. Phillip J.Rose, Taguchi techniques for quality engineering, McGraw Hill, 1996.
3. Fundamentals of Quality control and improvement 2nd edition, Amitava Mitra, Pearson Education Asia, 2002.
4. Rao, Singaresu, S., “Engineering Optimization – Theory & Practice”, New Age International (P) Limited, New Delhi, 2000.
5. Johnson Ray, C., “Optimum design of mechanical elements”, Wiley, John & Sons, 1990.
6. Kalyanamoy Deb, “Optimization for Engineering design algorithms and Examples”, Prentice Hall of India Pvt. 1995.
7. Goldberg, D.E., “Genetic algorithms in search, optimization and machine”, Barmen, Addison- Wesley, New York, 1989.

<b>ME125</b>	<b>SUSTAINABLE MANUFACTURING</b>					
<b>(Program Elective-III)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To understand the fundamentals of Sustainable Manufacturing and various tools and techniques of sustainability.
- To know the principles of sustainable design
- To understand the role of customer and user needs assessment for sustainability

**Course outcomes:** After completion of the course student will be able to:

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Summarize the basic concepts in sustainability	L2
CO2	Apply sustainable engineering design tools for life cycle assessment (LCA) and examine the features of various LCA Software	L3
CO3	Interpret the Principles of Sustainable Breakthrough Design	L3
CO4	Summarize the various design concepts for sustainability	L2
CO5	Identify Customer and User Needs Assessment for sustainable manufacturing	L2

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	2	1	1	1
<b>CO2</b>	3	2	3	3	1
<b>CO3</b>	3	1	2	1	
<b>CO4</b>	3	2	1	1	1
<b>CO 5</b>	3	3	2	1	1

**UNIT-I: Basic Concepts in Sustainability**

Understanding the language of sustainable engineering design, construction and operation. Natural resources terminology. Carrying capacity. Sustainable development, corporate responsibility, biophysical constraints, environmental management.

**UNIT-II: Tools and Techniques of Sustainability**

Sustainable Engineering Design Tools – Life cycle analysis, carbon foot printing. Life cycle assessment (LCA), Types of LCA's: baseline, comparative, streamlined. LCA inventory analysis: process or input- output. Hybrid inventory analysis. Sustainable Product Design. Whole systems design. Light weighting and materials reduction. Designing for a lifetime. Design for durability, repair and upgrade, disassembly and recycling. Energy use in design. Reducing energy losses in design.

**UNIT- III: Foundational Concepts & Principles for Sustainable Breakthrough Design**

Infrastructure for managing flows of materials, energy and activities; sustainable value creation approaches for all stakeholders, environmental design characteristics; design changes & continual improvement; inclusive sustainable design principles, crowd sourcing, multiple-objective designs; infrastructures that support system thinking; knowledge management for sustainable design, learning systems and experimentation; smart data systems, understanding variation.

**UNIT-IV: Sustainable Design**

Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, etc.

**UNIT-V: Customer and User Needs Assessment**

Identification & breakdown structures that describe customers & stakeholders, green marketing, socially conscious consumerism, sources of customer information, collecting information, analyzing customer behaviour, translating the voice of the customer, use analysis, structuring customer needs, service gap analysis, prioritizing customer needs, strategic design, Kano technique.

**Suggested Readings:**

1. Clarke, Abigail & John K. Gershenson Design for the Life Cycle, Life-cycle Engineering Laboratory, Department of Mechanical Engineering-Engineering Mechanics, 2<sup>nd</sup> Edition, Michigan Technological University, 2007.
2. Finster, Mark P., Sustainable Perspectives to Design and Innovation, 2013.
3. Ramaswamy, Rohit, Design and Management of Service Processes: Keeping Customers for Life, 1<sup>st</sup> Edition, Prentice Hall 1996.
4. Schmitt, Brent, Customer Experience Management, 1<sup>st</sup> Edition, Wiley and Sons, 2003.

<b>ME 151</b>	<b>PRODUCTION ENGINEERING LAB</b>					
<b>Pre-requisites</b>	-		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			-	-	2	1
<b>Evaluation</b>	<b>SEE</b>	-	<b>CIE</b>	50		

**Objectives:**

- Study the chip morphology and evaluate chip thickness and shear angle
- Perform formability studies on sheet metals.
- Perform experiments on CNC lathe and Mill.
- Evaluate the mechanical properties of welded joints
- Test the properties of moulding sands and tribological properties of a given material

**Course Outcomes:** After completion of the course student will be able to

1. Ability to perform simulations/ experiment and understand the phenomenon
2. Critically evaluate and interpret the results
3. Prepare a well-organized record

**List of Experiments:**

1. Study of the morphology of chips produced from different materials and machining processes.
2. Study of cutting ratio/chip thickness ratio in simulated orthogonal cutting with different materials and tool geometry.
3. Roughness of machined surface. Influence of tool geometry and feed rate
4. Study of cutting forces using Lathe tool dynamometer by varying machining parameters.
5. Study of the construction and operating parameters of metal spinning Lathe.
6. Study of the water hammer equipment and hydrostatic extrusion setup.
7. Extrusion of cylindrical billets through dies of different included angles and exit diameters and their effect on extrusion pressure.
8. Practice and study of blanking and punching process and their characteristic features on mechanical press with existing dies.
9. Experiments on EDM to measure MRR and Surface roughness of different metals.
10. Programming and experiments on CNC milling for different profiles.
11. Programming and experiments on CNC lathe for cylindrical jobs.
12. Experiments on MIG/MAG welding to find out the mechanical properties of metals.
13. Testing of mechanical properties of metals by using UTM.
14. Fatigue Testing of metals on Rotary Fatigue Testing Machine.

*With effect from the Academic year 2023-2024*

15. Evaluation of moulding sand properties by varying the silica, clay and binder proportions
16. Evaluation wear characteristics of cutting tool materials using PIN on DISC and Abrasion Tester.



<b>ME 161</b>	<b>SEMINAR</b>					
<b>Pre-requisites</b>	-		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			-	-	2	1
<b>Evaluation</b>	<b>SEE</b>	-	<b>CIE</b>	50		

**Course Objectives:**

- Identify appropriate topic of relevance.
- Update literature on technical articles of selected topic and develop comprehension.
- Prepare a technical report.
- Deliver presentation on specified technical topic.

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	<i>Identify and compare technical and practical issues related to manufacturing and production Engineering related systems.</i>	L2
CO2	<i>Interpret the working of Manufacturing systems.</i>	L2
CO3	<i>Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.</i>	L3
CO4	<i>Criticize and experiment to arrive at solutions for real world Production engineering problems.</i>	L4
CO5	<i>Analyse and evaluate to obtain solution for problems in Production systems.</i>	L4

Seminar topics may be chosen by the students with advice from the faculty members and the student shall read further relevant articles in the domain.

***The seminar must be clearly structured and the power point presentation shall include following aspects:***

1. Introduction to the field
2. Literature survey
3. Consolidation of available information
4. Objectives and Methodology
5. Results and Discussions& Summary
6. Conclusions
7. References

***Each student is required to:***

1. Deliver the seminar for a maximum duration of 30 minutes, where the presentation should be for 20 minutes in PowerPoint, followed by Question and Answers session for 10 minutes.
2. Submit the detailed report of the seminar in spiral bound in a précised format as suggested by the Department.

<b>Guidelines for awarding marks</b>		
<b>S. No.</b>	<b>Description</b>	<b>Max. Marks</b>
1	Contents and relevance	10
2	Presentation skills	10
3	Preparation of PPT slides	05
4	Questions and answers	05
5	Report in a prescribed format	20

**Note:**

1. The seminar presentation should be a gist of at least five research papers from Peer-reviewed or UGC recognised journals.
2. The seminar report should be in the following order: Background of work, literature review, techniques used, prospective deliverables, discussion on results, conclusions, critical appraisal and reference.
3. At least two faculty members will be associated with the seminar presentation to evaluate and award marks.
4. Attendance of all the students for weekly seminar presentations is compulsory.

**SEMESTER - II**

<b>ME104</b>	<b>PRODUCT DESIGN AND PROCESS PLANNING</b>					
<b>(Core-IV)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To learn the essential factors with innovative ideas to develop successive right product.
- To acquaint with product reliability, copyrights, value Engineering in product design and cost estimation of product.
- To understand the various machining processes, improving tolerances methods, selection of materials and their importance.
- To understand the modern approaches, ergonomics considerations in product design, integration of design, manufacturing and production control.

**Course Outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
C01	Identify and analyze the product design and development processes in manufacturing industry	L3
C02	Perform function analysis to improve the value of the product, estimate the cost of the product and be familiar with the Intellectual Property rights	L2
C03	Suggest an appropriate manufacturing process for a given product using product design rules of various manufacturing process	L4
C04	Understand the importance of ergonomics in the design of new products	L2
C05	Comprehend the role of computer in product design, Manufacturing and Management	L2

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1		1	1	1
<b>CO2</b>	2		2	2	3
<b>CO3</b>	1	1	2	3	2
<b>CO4</b>	1	1	3	3	2
<b>CO5</b>	2		3	3	3

**UNIT - I**

Introduction to product design, Design by Evolution, Design by Innovation, Essential factors of product design, Production-Consumption Cycle, Morphology of design, evaluation of new product ideas. Analysis of the product, The Three S's Product reliability, Mortality Curve, Reliability systems, Manufacturing reliability and quality control.

#### **UNIT - II**

Patents: Definitions, classes of patents, applying for patents. Trademarks and copyrights. Cost and quality sensitivity of products, Elements of cost of a product, costing methods, cost reduction and cost control activities. Economic analysis, Break even analysis Charts. Value engineering in product design, Case study, Function analysis system technique (FAST) Procedures of value analysis – cost reduction, material and process selection.

#### **UNIT - III**

Various manufacturing processes, degree of accuracy and finish obtainable, process capability studies. Basic product design rules for Casting, Forging, Machining, Sheet metal and Welding. Physical properties of engineering materials and their importance on products. Selection of plastics, rubber and ceramics for product design.

#### **UNIT - IV**

Industrial ergonomics: Man-machine considerations, ease of maintenance. Ergonomic considerations in product design- Anthropometry, Design of controls, man-machine information exchange. Process sheet detail and their importance, Value of appearance, colours and Laws of appearance. advanced techniques for higher productivity. Just -in -time and Kanban System.

#### **UNIT - V**

Role of computer in product design, Manufacturing and Management. Modern approaches to product design; quality function development, Rapid prototyping. Computer Integrated Manufacturing, communication network, production flow analysis, Group Technology, Computer Aided process Planning. Flexible manufacturing system

#### **Suggested Reading:**

1. Chitale, A.K, and Gupta, R.C., Product Design and Manufacturing, 5<sup>th</sup> Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2011.
2. Karl T Ulrich, Steven D Eppinger, "Product Design & Development." 7<sup>th</sup> Edition, Tata McGrawhill New Delhi, 2020.
3. Mahajan, M. Industrial Engineering and Production Management, 1<sup>st</sup> Edition, Dhanpath Rai & Co., 2014.
4. Anil Kumar Mukhopadhyaya, Value Engineering Mastermind- From Concept to Value Engineering Certification, 1<sup>st</sup> Edition, SAGE Publications Ltd, 2009.

<b>ME105</b>	<b>COMPUTER AIDED MANUFACTURING</b>					
<b>(CORE-V)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- Provide concepts and knowledge in computer aided manufacturing
- Apply CAD/CAM concepts to product design and manufacturing
- Learn working principles of NC machines CNC control and part programming
- Analyse concepts of Group Technology, FMS and CIM

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Bloom s Level</b>
C01	Describe basic concepts of CAM and demonstrate engineering design concepts	L2
C02	Apply Product specification methods in design	L4
C03	Develop CNC programs for manufacturing of different geometries	L3
C04	Describe process planning	L3
C05	Explore the application of PPC, JIT, MRP-I, MRP-II, and Expert system to CAM	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	2	2	2	
<b>CO2</b>	3	3	2	2	
<b>CO3</b>	3	3	2	2	
<b>CO4</b>	3	3	2	2	
<b>CO 5</b>	3	3	2	2	

**UNIT-I**

**Computer Aided Manufacturing:** CAM Concepts, Objectives & scope, Nature & Type of manufacturing system, Evolution, Benefits of CAM, Role of management in CAM, Concepts of Computer Integrated Manufacturing, Impact of CIM on personnel, Role of manufacturing engineers.

#### **UNIT-II**

**NC/CNC Machine Tools:** NC and CNC Technology: Types, Classification, Specification and components, Construction Details, Controllers, Sensors and Actuators, CNC hardware: Re circulating ball screw, anti friction slides, step/servo motors. Axis designation, NC/CNC tooling. Fundamentals of Part programming, Types of format, Part Programming for drilling, lathe and milling machine operations, subroutines, do loops.

#### **UNIT-III**

**DNC Systems and Adaptive Control:** Introduction, type of DNC systems, advantages and disadvantages of DNC, adaptive control with optimization, Adaptive control with constraints, Adaptive control of machining processes like turning, grinding. Post Processors for CNC: Introduction to Post Processors: The necessity of a Post Processor, the general structure of a Post Processor, the functions of a Post Processor, DAPP — based- Post Processor

#### **UNIT – IV**

**Micro Controllers:** Introduction, Hardware components, selection of Micro Controllers, Applications, and Programming of Micro Controllers. Programming Logic Controllers (PLC's): Introduction, Hardware components of PLC, System, basic structure, principle of operations, Programming mnemonics timers, Internal relays and counters, Applications of PLC's in CNC Machines.

#### **UNIT – V**

**Integrated Production Management System:** Introduction, PPC fundamentals, Problems with PPC, MRP-I, MRP-II. Just in Time philosophy: JIT & GT applied to FMS, concepts of Expert System in Manufacturing and Management Information System.

#### **Suggested Reading:**

1. P.N. Rao, N. K. Tewari, T K Kundra “ Computer Aided Manufacturing” 2<sup>nd</sup> Edition, McGraw Hill, 2017.
2. P.N. Rao, CAD/CAM Principles and Applications, 3<sup>rd</sup> Edition, TMH, 2017.
3. Hsu Pin Wang, Richard A. Wysk, Tien Chien Chang, Computer-Aided Manufacturing 3rd Edition, Hardcover, Pearson Education 2005.
4. Yoram Koren, Computer Control of Manufacturing Systems, 1<sup>st</sup> Edition, McGraw Hill, 1983
5. Radha krishnan and Subramanian, CAD / CAM / CIM, 1<sup>st</sup> Edition, New Age

International Publishers, 2007.

6. Mikell P Groover, Automation, Production Systems and Computer Integrated Manufacturing ,4<sup>th</sup> Edition, Pearson Education, 2016.
7. P. Radhakrishnan, " Computer Numerical Control ", 1<sup>st</sup> Edition, New Central Book Agency, 2013.
8. S. Kant Vajpayee, Computer integrated manufacturing, 1<sup>st</sup> Edition, Prentice Hall of India, 1998.
9. Nanua Singh, System Approach to Computer Integrated Manufacturing, Volume 28,Wiley and sons Inc, 1996.
10. Ibrahim Zeid, R.Sivasubramanian, CAD/CAM : Theory & Practice, 2<sup>nd</sup> Edition, Tata McGraw Hill, 2009.

<b>ME106</b>	<b>ADDITIVE MANUFACTURING TECHNOLOGIES AND APPLICATIONS</b>					
<b>(CORE-VI)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To know the fundamentals of Additive Manufacturing (AM) and compare it with conventional CNC technology
- To understand the working principle, advantages, limitations and applications of various AM Technologies and also various types of data formats and errors.
- To know the role of AM in Topology optimization and understand the applications of AM in various fields like Biomedical, Aerospace, Automobile and other domains.

**Course outcomes:** After completion of the course student will be able to:

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
C01	Interpret the features of Additive Manufacturing and compare it with conventional CNC Technology	L2
C02	Illustrate the working principle, advantages, limitations and applications of various Additive Manufacturing Technologies and Rapid Tooling systems	L2
C03	Interpret various types data formats and STL file errors used in AM and identify the role of Topology optimization in AM	L3
C04	Analyze the features of different types of software's used in 3D Printing	L4
C05	Apply the knowledge of various AM technologies for developing new and innovative applications	L3

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	2		2	1	1
<b>CO2</b>	3	2	2	3	2
<b>CO3</b>	2	1	2	3	2
<b>CO4</b>	2	2	2	3	1
<b>CO 5</b>	2	1	2	2	2

**UNIT – I**

**Introduction:** Prototyping fundamentals: Need for time compression in product development, Need for Additive Manufacturing, Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Commonly used



Terms, Classification of AM process, Fundamental Automated Processes: Distinction between AM and CNC, other related technologies. Role of AM in Industry 4.0.

## **UNIT – II**

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies

**Vat Photo polymerization AM Systems:** Photopolymers, photo polymerization Stereo lithography Apparatus (SLA), Direct Light Processing (DLP) and Continuous Direct Light Processing (CDLP).

**Material Jetting AM Systems:** Material Jetting, Nano particle jetting and Drop-On-Demand (DOD) material jetting **Binder Jetting AM Systems:** Three-dimensional Printing (3DP).

**Material Extrusion AM Systems:** Fused Deposition Modeling (FDM)

## **UNIT – III**

Working principle, Specifications, Materials used, Process, Applications, Advantages and Disadvantages, Case studies of the following AM Technologies

**Powder Bed Fusion AM Systems:** Selective laser sintering (SLS), Selective Laser Melting (SLM) and Direct Metal Laser Sintering (DMLS), Electron Beam Melting (EBM).

**Direct Energy Deposition (DED) AM Systems:** Laser Engineered Net Shaping (LENS) and Electron Beam Additive Manufacturing (EBAM).

**Sheet Lamination AM Systems:** Laminated Object Manufacturing (LOM) and Ultrasonic Additive Manufacturing (UAM).

**Rapid Tooling:** Introduction to Rapid Tooling (RT), Conventional Tooling Vs RT, Need for RT, Classification of Rapid Tooling, Direct and Indirect Tooling Methods, Soft and Hard Tooling methods.

## **UNIT – IV**

**Reengineering in AM:** Reengineering *Engineering (RE) Methodologies and Techniques, Selection of RE systems, RE software, RE hardware, RE in product development*

**AM Data Formats:** *STL Format, STL File Problems, Consequence of Building Valid and Invalid Tessellated Models, STL file Repairs: Generic Solution, Slicing Algorithms: Rock Algorithm, Crawford's algorithm, Other Translators, Newly Proposed Formats. Mesh Refining by Sub division Techniques, Topology optimization and Additive Manufacturing.*

**AM Software's:** *Need for AM software, Features of various AM software's like Magics, Mimics, Solid View, View Expert, 3 D View, Velocity 2, Rhino, STL View 3 Data Expert and 3 D doctor, SurgiGuide, 3-matic, Simplant, MeshLab.*

## **UNIT –V**

**AM Applications:** Application – Material Relationship, Application in Design, Engineering Analysis and Planning, Aerospace, Automotive, Jewelry, Coin, GIS, Arts, Architecture. Medical and Bioengineering Applications, Forensic Science and Anthropology, Visualization of Biomolecules.

**Cost Estimation in AM:** Cost Model, Build Time Model, Laser Scanning Vat Photopolymerization Example, Life-Cycle Costing.

**Suggested Readings:**

1. Ian Gibson, David W Rosen, Brent Stucker, “Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing”, Second Edition, Springer, 2010.
2. Chee Kai Chua and Kah Fai Leong, “3D Printing and Additive Manufacturing Principles and Applications” Fifth Edition, World scientific, 2017.
3. Frank W.Liou “Rapid Prototyping & Engineering Applications”, Second Edition, CRC Press, Taylor & Francis Group, 2019.
4. Rafiq Noorani, “Rapid Prototyping: Principles and Applications in Manufacturing”, First Edition, John Wiley & Sons, 2006.
5. NPTEL Course on Rapid Manufacturing.

<b>ME126</b>	<b>EXPERIMENTAL TECHNIQUES AND DATA ANALYSIS</b>					
<b>(Program Elective-IV)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course objectives:**

- To familiarize students with the machining processes forces on machine tool structures
- To understand the various process parameters affecting the components manufacturing both internal structure and external form features
- To study the effects of variables in experimental design methods and its verification tests
- To identify the robust method of experiment that given reliable and acceptable results

**Course Outcomes:**

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Estimate cutting force using strain gauges, transducers and strain by photo elasticity, holography, interferometer, Strain gauges.	L2
CO2	Estimate temperature by thermistors, electrical resistance, pyrometers, thermo couples, bimetallic etc and flow measurement by laser dopler, hot wire anemometer, ultrasonic, shadow graphs.	L4
CO3	Examine the microstructure of a given material under different working condition and Measurement of surface finish and surface roughness.	L3
CO4	Propose an appropriate statistical model for a given experimental data and estimate the contribution of each parameter by ANOVA	L3
CO5	Apply orthogonal array, optimize the response function and estimate loss function for experimental design	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1		3	1	3
<b>CO2</b>	1		3	2	3
<b>CO3</b>	2		3	3	3
<b>CO4</b>	1	1	2	2	2
<b>CO 5</b>	2	1	2	2	3

### **UNIT – I**

**Measurement of Cutting Forces:** Strain gauge and piezoelectric transducers and their characteristics. Dynamometer construction, Bridge circuits. Instrumentation and calibration. Displacement and strain measurements by photo-elasticity. Holography, interferometer, Moiré techniques, strain gauge rosettes.

### **UNIT – II**

**Temperature Measurement:** Circuits and instrumentation for different transducers viz, bimetallic, expanding fluid, electrical resistance, thermistor, thermocouples, pyrometers. **Flow Measurement:** Transducers for flow measurements of Non-compressible and compressible fluids. Obstruction and drag methods. Vortex shedding flow meters. Ultrasonic, Laser Doppler and Hotwire anemometer. Flow visualization techniques, Shadow graphs, Schlieren photography. Interferometer.

### **UNIT – III**

**Metallurgical Studies:** Optical microscopy, Scanning Electron Microscopy and Transmission Electron Microscopy, X-Ray diffraction, Bragg's Law and its application for studying crystal structure and residual stresses. Electron spectroscopy, **Surface Measurements:** Micro hardness, roughness, accuracy of dimensions and forms. 3-D co-ordinate measuring machines.

### **UNIT - IV**

**Experiment design & data analysis:** Statistical methods, Randomized block design, Latin and orthogonal squares, factorial design, Replication and randomization, response surface methodology. **Data Analysis:** Deterministic and random data, uncertainty analysis, tests for significance: Chi-square, student's t-test. Regression modeling, direct and interaction effects. ANOVA, F-test. Time Series analysis, Autocorrelation and autoregressive modeling.

### **UNIT – V**

**Taguchi Methods:** Experiment design and planning with orthogonal arrays and linear graphs. Additive cause effect model. Optimization of response level. Identification of Design and noise factors. Performance evaluation and Optimization by signal to noise ratios. Concept of loss function and its application.

### **Suggested Reading:**

1. Holman, J.P.: Experimental Methods for Engineers, 8<sup>th</sup> Edition, McGraw Hill Int., New York, 2012.
2. Venkatesh, V.C., and Chandrasekharan, Experimental Methods in Metal Cutting, 1<sup>st</sup> Edition, Prentice Hall of India, Delhi, 1982.
3. Raymond H. Mayers, Douglas C. Montgomery, Christine M. Anderson-Cook, Response Surface Methodology: Process and Product Optimization using Designed Experiment, 3<sup>rd</sup> edition, John Wiley & Sons, New York, 2001

4. D.C. Montgomery, Design and Analysis of Experiments, 5th edition, John Wiley & Sons, New York, 2001
5. A.M. Dean, and D. T.Voss, Design and Analysis of Experiments (Springer text in Statistics), 1<sup>st</sup> Edition, Springer, 1999.
6. Tapan P. Bagchi, Taguchi Methods Explained, 1<sup>st</sup> Edition, Prentice Hall of India, Delhi, 1993.

<b>ME127</b>	<b>NON-DESTRUCTIVE EVALUATION TECHNIQUES</b>					
<b>(Program Elective-IV)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

### Course Objectives

- To understand the need of NDT for defect detection in Industry.
- To learn the principles and techniques and applications of contact and Non-Contact type of NDT methods.
- To know the reference standards used for calibration and specifications related to NDT technology.
- To know the appropriate NDT method for various Industrial Inspection needs.

**Course Outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
C01	Comprehend the basic principles of non-destructive testing (NDT) methods	L2
C02	Identify appropriate nondestructive testing methods for failure identification	L2
C03	Select NDT methods for quality analysis of industrial components	L3
C04	Analyse and interpret results from various NDT techniques along with calibration of these NDT.	L4
C05	Illustrate the advanced NDT techniques used in medical and non-medical field.	L2

### Program Articulation Matrix

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3		3	3	1
<b>CO2</b>	3		3	2	1
<b>CO3</b>	3		2	2	1
<b>CO4</b>	1		2	2	1
<b>CO 5</b>	1		2	2	1

### **UNIT-I**

**Types of defects and characteristics**, Quantification aspects relevant for NDE including fracture aspects and stress intensity factors - NDT overview – quality assurance–visual inspection–comparative features of conventional Non-destructive Testing and Evaluation Methods including Optical, Radiography, Ultrasonic Testing, Dye penetrant testing, Eddy current testing etc.

### **UNIT-II**

**Leak testing – liquid penetrant testing** – penetrant used – equipment – penetration, emulsification, solvent removal. **Eddy current testing** – material conductivity – coil impedance–coils and instruments–testing in non-ferromagnetic conducting materials and ferro magnetic materials – skin effect – frequency used – inspection probes – phase analysis. **Magnetic particle testing**–magnetization methods–continuous and residual methods – sensitivity – demagnetization.

### **UNIT-III**

**Radiography**–sources of radiation–shadow formation, enlargement and distortion – recording media – exposures, markers. **Ultrasonic testing** – generation of ultrasound – methodologies – transducers and equipment used – flaw detection - sensitivity and calibration. Computer aided image processing methods for radiography and ultrasonics, tomography in these areas. .

### **UNIT-IV**

**Optical techniques of non-destructive evaluation:** Machine Vision-system components, Sensors, specifications for resolution & range. Use of fibreoptics, Principles of Photo elasticity, holographic Interferometry; Laser speckle techniques and shearography, Grid and Moiré NDT.

### **UNIT-V**

**Principles of acoustic emission techniques** – Instrumentation-analysis methods, Thermal testing: Infrared and Microwave Thermography– imaging systems – detectors – analysis methods, non-invasive techniques in medical field and NDT.

### **Suggested Readings:**

1. Barry Hull, “Non-Destructive Testing”, 1<sup>st</sup> Edition, Vernon John, ELBS/ Macmillan, 1988.
2. J. Prasad, C.G.K. Nair: Non-Destructive Testing and Evaluation of Materials, 2<sup>nd</sup> Edition, Tata McGraw Hill, 2011
3. Paul E. Mix: Introduction to Non-destructive Testing- A Training Guide, 2<sup>nd</sup> Edition, John Wiley & Sons, 2005.
4. Louis Cartz: Nondestructive testing- radiography, ultrasonics, liquid penetrant, magnetic particle, eddy current, 1<sup>st</sup> Edition, ASM International, 1995.
5. ASM Metals Handbook, Vol 17: Non-Destructive Examination and Quality Control, 9<sup>th</sup> Edition, ASM, 1989.
6. Don.E. Bray, Roderic K. Stanley: Nondestructive Evaluation- A Tool in Design, Manufacturing, and Service, Revised Edition, CRC Press, 1997.

<b>(Program Elective-IV)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To familiarize students with the displacement-based finite element method for displacement and stress analysis and to introduce related analytical and computer tools.
- To provides a bridge between hand calculations and numerical solutions for more complex geometries and loading states.
- To study approximate nature of the finite element method and convergence of results are examined.
- It provides some experience with a commercial FEM code and some practical modeling exercises.

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Bloom s Level</b>
CO1	summarize the basics of finite element formulation	L2
CO2	derive interpolation functions and characteristic matrices for different 1D, 2D and 3D elements.	L4
CO3	apply the knowledge in solving one dimension and two-dimensional static stress and dynamic analysis problems.	L3
CO4	solve the steady state and transient heat transfer analysis using FEA.	L3
CO5	analyze three-dimensional stress analysis and fluid flow problems.	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	3	2	2	2	
<b>CO2</b>	3	3	2	2	
<b>CO3</b>	3	3	2	2	
<b>CO4</b>	3	3	2	2	
<b>CO 5</b>	3	3	2	2	

**UNIT-I**

**Introduction:** Historical Background, General description of the finite element method, Mathematical Modeling of field problems in Engineering, Governing Equations, Discrete and continuous models, Boundary, Initial and Eigen Value problems, Weighted Residual Methods,



Variational Formulation of Boundary Value Problems, Potential energy method, Rayleigh Ritz method, Galerkin's method of finite element formulation. Strain displacement relations, Stress strain relations, Interpolation models: Simplex, complex and multiplex elements, Linear interpolation polynomials in terms of local, natural and global coordinates for 1D, 2D, 3D Simplex Elements. Finite element equations, treatment of boundary conditions.

## **UNIT-II**

One-Dimensional Elements-Analysis of Bars and Trusses, Linear interpolation polynomials in terms of local coordinate's for 1D, 2D elements. Higher order interpolation functions for 1D quadratic and cubic elements in natural coordinates, Analysis of plane truss with number of unknowns not exceeding two at each node. Analysis of frames with two translations and a rotational degree of freedom at each node. Analysis of Beams: Element stiffness matrix for two noded, two degrees of freedom per node for beam element. Torsion of Shafts: Finite element formulation of shafts, determination of stress and twists in circular shafts.

## **UNIT-III**

Finite element modeling of two-dimensional stress analysis problems with constant strain triangles and treatment of boundary conditions. Two dimensional four noded iso-parametric elements and numerical integration. Plane stress, plane strain and axi-symmetric problems, Body forces and temperature effects. Stress calculations, Plate and shell elements. Elements. Convergence requirements and geometric isotropy. Application to Field Problems, Thermal problems, Analysis of a uniform shaft subjected to torsion using Finite Element Analysis. Quadrilateral elements and Higher Order Elements.

## **UNIT-IV**

Steady state heat transfer analysis: One dimensional analysis of a fin, composite walls and two-dimensional conduction analysis of thin plate. Time dependent field problems: Application to one dimensional heat flow in a rod. Dynamic analysis: Formulation of finite element modeling of Eigen value problem for a stepped bar and beam. Evaluation of Eigen values and Eigen vectors.

## **UNIT-V**

Finite element formulation of three-dimensional problems in stress analysis. Fluid Flow: Flow through a porous medium, Flow through pipes of uniform and stepped sections, Flow through hydraulic networks. Finite Element formulation of an incompressible fluid. Potential flow problems Bending of elastic plates. Introduction to non-linear problems and Finite Element analysis software.

### **Suggested Readings:**

1. Tirupathi R Chandraputla and Ashok. D.Belegundu, Introduction of Finite Element In Engineering", Third Edition, Prentice Hall of India, 2002.

2. Rao S.S., “The Finite Element Methods in Engineering”, Fifth Edition, Pergamon Press, 2010.
3. Segerl and. L.J., “Applied Finite Element Analysis”, Second Edition, Wiley Publication,1984.
4. Reddy J.N., “An Introduction to Finite Element Methods”, Fourth Edition, Mc Graw Hill Company,2020.
5. P.Seshu, “Text book of Finite Element Analysis”, Tenth Edition, PHI Learning Pvt. Ltd., 2012.

(Program Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

**Course Objectives:**

- The objective of course is identify the manufacturing constraints that influence the design of parts and part systems.
- Students will be introduced to the Design for Manufacturability (DFM) methodology, and will be motivated to understand infeasible or impractical designs.

**Course Outcomes:** After completion of the course student will be able to

1. Understand the quality aspects of design for manufacture and assembly.
2. Apply Boothroyd method of DFM for product design and assembly.
3. Apply the concept of DFM for casting, welding, forming and assembly.
4. Identify the design factors and processes as per customer specifications.
5. Apply the DFM method for a given product.

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	2	2	
CO2	3	3	2	2	
CO3	3	3	2	2	
CO4	3	3	2	2	
CO 5	3	3	2	2	

**UNIT - I**

**Introduction:** Design philosophy steps in Design process - General Design rules for manufacturability - basic principles of design Ling for economical production - creativity in design.

**Materials:** Selection of Materials for design Developments in Material technology - criteria for material selection - Material selection interrelationship with process selection process selection charts.

**UNIT - II**

**Machining Process:** Overview of various machining processes - general design rules for machining - Dimensional tolerance and surface roughness - Design for machining - Ease -

Redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

**Metal Casting:** Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting.

### UNIT - III

**Metal Joining:** Appraisal of various welding processes, Factors in design of weldments - general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints.

**Forging -** Design factors for Forging - Closed dies forging design - parting lines of die5 drop forging die design - general design recommendations. Extrusion & Sheet Metal Work: Design guidelines for extruded sections - design principles for Punching, Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.

### UNIT- IV

**Assemble Advantages:** Development of the assemble process, choice of assemble method assemble advantages social effects of automation.

**Automatic Assembly Transfer Systems:** Continuous transfer, intermittent transfer, indexing mechanisms, and operator - paced free – transfer machine.

### UNIT - V:

**Design of Manual Assembly:** Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.

### REFERENCES:

1. Assembly Automation and Product Design/ Geoffrey Boothroyd/ Marcel Dekker Inc., NY, 1992.
2. Engineering Design - Material & Processing Approach/ George E. Deiter/McGraw Hill Intl. 2<sup>nd</sup> Ed. 2000.
3. Hand Book of Product Design/ Geoffrey Boothroyd/ Marcel and Dekken, N.Y. 1990.
4. Computer Aided Assembly London/ A Delbainbre/.
5. Product Design for Manufacturing and Assembly/ Geoffrey Boothroyd, Peter Dewhurst & Winston Anstony Knight/CRC Press/2010

ME129	MACHINE TOOL DYNAMICS
(Program Elective-IV)	

<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To learn machine tool structure vibration
- To learn causes and types of vibration machine tool structures
- To find suitable methods solve the vibration of structures
- To mitigate the vibration of machine tool structures

**Course Outcome**

CO's	Description	Blooms Level
CO1	Learn vibration of machine tool structures	L3
CO2	understand the causes of machine tool structures	L3
CO3	analyse and evaluate the machine tool vibrations	L4
CO4	design suitable damping procedure to mitigate machine tool vibration	L3
CO5	Able to identify any vibration of machine motion and make correction	L4

**Program Articulation Matrix**

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	3	2	1	3
CO2	2	2	2	1	3
CO3	3	2	1	2	3
CO4	2	3	2	1	3
CO5	3	3	3	2	3

**UNIT-I**

**Vibration theory:** Review of systems with one and two degrees of freedom, damped, undamped free and forced vibrations, beat phenomenon. Transmissibility of vibration and vibration isolation. Vibration measurement.

**UNIT-II**

**Dynamics of structures:** Force and stiffness methods, Eigen value problem using lumped mass technique, application to simple structures with damping.

**UNIT-III**

**Chatter in Machine Tools:** Basic pattern of chatter in metal cutting. Regenerative chatter, node coupling. Limit width of cut. Importance of negative real component of receptance. Dynamic cutting force co-efficient. Prediction of machine tools instability. Study of chatter behavior of lathe, drilling and milling machines. C.I.R.P., rig stick-slip phenomenon.

**UNIT-IV Stability of Machine tools:** Individual steps in the procedure-Directional factors cutting tests, Measurement of dynamic data by excitation tests. Evaluation of the test examples of the analysis of the stability of machine tools like Horizontal knee-type milling machine, vertical knee-type milling machine, center lathes.

**UNIT-V**

**Damping in Machine Tools:** Material and system damping. Dampers – Dynamic, impact and active type. Methods of improving damping in machine tools. Examples of the use of dampers, practical design consideration. Dynamic measurement of forces and vibration – Oscillating tools. Vibration isolation system.

**Suggested Reading:**

1. F.Keeningsberger and J. Tlusty, Machine Tool Structure, Volume 1,Porgamon press, 1970.
2. G.Sweeney, Vibration of Machine Tools, 1<sup>st</sup> Edition, Machinery Publishing Co. 1971.
3. Walter C. Hurty and M.F. Bubinstein, Dynamics of Structures, 2<sup>nd</sup> Edition, Prentice Hall, 1967.
4. W.T.Thomson, Vibration Theory And Applications, Revised Edition, Prentice Hall, 1965.
5. S.A. Tobias, Machine Tool Vibrations, 1<sup>st</sup> Edition, Blackie publications, 1965.

<b>ME130</b>	<b>SMART MATERIALS AND MEMS</b>				
<b>(Program Elective-V)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>

			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- This course provides a detailed overview to smart materials, piezoelectric materials structures and its characteristics.
- To study of Smart structures and modeling helps in Vibration control using smart materials in various applications.
- To familiarize with various microelectronic mechanical systems which find extensive usage in industrial applications.
- to understand the principles and concepts of using MEMS, ER & MR Fluids for various applications

**Course outcomes:** After completion of the course student will be able to

CO's	Description	Blooms Level
CO1	Describe the overview of different kinds of smart materials and their applications	L2
CO2	Explain the principle concepts of Smart materials, structures, Fibre optics, ER & MR Fluids, Biomimetics and MEMS with principles of working.	L3
CO3	Describe the various fabrication processes of smart materials and MEMS	L2
CO4	Analyze the properties of smart structures, MEMS, with the applications and select suitable procedure for fabrication.	L4
CO5	Summarize the methods and uses of Micro fabrications, Biomimetics, types of polymers used in MEMS, Fibre optics, piezoelectric sensing and actuation.	L4

**Program Articulation Matrix**

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
<b>CO1</b>	3		2		1
<b>CO2</b>	3				2
<b>CO3</b>	3		2		
<b>CO4</b>	3		1		2
<b>CO 5</b>	3			1	3

**UNIT I**

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

**UNIT II**

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

**UNIT III**

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

**UNIT IV**

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

**UNIT V**

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

**Suggested Reading:**

1. Donald J. Leo, Engineering analysis of smart material systems, 1<sup>st</sup> Edition, John Wiley Sons, 2007.
2. R.C. Smith, Smart material systems: model development, 1<sup>st</sup> Edition, SIAM, 2005.
3. S.D. Senturia, Microsystem Design, 2<sup>nd</sup> Edition, Kluwer Academic Publishers, 2004.
4. Tai-Ran Hsu, MEMS & Microsystems Design and Manufacture, 1<sup>st</sup> Edition, McGraw Hill, 2002.
5. V.K. Varadan, K.J. Vinoy, and S. Gopalakrishnan, Smart Material Systems and MEMS: Desig and Development Methodologies, 1<sup>st</sup> Edition, Wiley, 2006.

ME131	MICRO AND NANO MANUFACTURING				
(Program Elective-V)					
Pre-requisites		L	T	P	C



			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To give awareness of different techniques used in micro and nano manufacturing.
- To introduce Non conventional micro nano manufacturing and finishing approaches.
- To introduce Nanofabrication Techniques and other processing routes in Micro and nano manufacturing.
- To know different techniques used in synthesis of nano- materials.

**Course Outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
C01	Differentiate Macro, micro operations and explain importance of precision in machining.	L2
C02	Analyze methods and tools for micro and nano-manufacturing.	L4
C03	Illustrate different techniques for the synthesis and processing of nano-materials	L2
C04	Select micro and nano-manufacturing methods and identify key variables to improve quality of MEMS	L3
C05	Select appropriate industrially viable process, equipment and tools for a specific product.	L4

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1		3		1
<b>CO2</b>	2		3		2
<b>CO3</b>	2		3		2
<b>CO4</b>	2		3		2
<b>CO 5</b>	2		3		2

**UNIT I**

**Micro Machining Techniques:**

**Introduction to Micro machining Techniques:** Principle and applications of Ultrasonic Micro Machining, Abrasive jet Micro machining, Electro discharge Micro machining,

Electrochemical Micro machining, Laser beam Micro machining, Electron Beam Micro machining, and **Ion Beam Machining (IBM)**.

## **UNIT II**

### **Micro Finishing Techniques:**

Introduction to Micro finishing Techniques: Principle and applications of Chemo-Mechanical Polishing (CMP), Abrasive flow finishing (AFF), Magnetic abrasive finishing (MAF), Magnetic Float polishing (MFP), and Magnetorheological finishing (MRF), Elastic Emission Techniques.

## **UNIT III**

**Introduction:** Importance of Nano-technology, Emergence of Nanotechnology, Bottom-up and Top-down approaches, challenges in Nanotechnology, Scaling Laws/Sizing effects.

**Nano-materials Synthesis and Processing:** Methods for creating Nanostructures; Processes for producing ultrafine powders- Mechanical grinding; Wet Chemical Synthesis of nano-materials sol-gel process, Liquid solid reactions; Gas Phase synthesis of nano-materials- Furnace, Flame assisted ultrasonic spray pyrolysis; Gas Condensation Processing (GPC), Chemical Vapour Condensation(CVC)- Cold Plasma Methods, Laser ablation, Vapour – liquid –solid growth, particle precipitation aided CVD, summary of Gas Condensation Processing(GPC).

## **UNIT IV**

**Micro fabrication Techniques:** Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Bulk Micromachining, Surface Micromachining, High- Aspect-Ratio Micromachining

## **UNIT V**

**Nanofabrication Techniques:** E-Beam and Nano-Imprint Fabrication, Epitaxy and Strain Engineering, Scanned Probe Techniques, Self-Assembly and Template Manufacturing.

**MEMS devices and applications:** Pressure sensor, inertial sensor, Optical MEMS and RFMEMS, Micro-actuators for dual-stage servo systems.

### **Suggested Reading:**

1. Marc Madou, Fundamentals of Micro-fabrication: The Science of Miniaturization, Second Edition CRC Press, 2002.
2. Mark James Jackson, Micro-fabrication and Nano-manufacturing, 2<sup>nd</sup> Edition, CRC Press, 2002.
3. Gabor L. Hornyak, H.F Tibbals, Joydeep Dutta & John J Moore, Introduction to Nano-science and Nanotechnology, 1<sup>st</sup> Edition, CRC Press, 2008.
4. Ray F. Egerton , Physical Principles of Electron Microscopy: An Introduction to TEM,SEM, and AEM , 1<sup>st</sup> Edition, Springer, 2005.

*With effect from the Academic year 2023-2024*

5. Robert F Speyer, Thermal Analysis of Materials, 1<sup>st</sup> Edition, Marcel Dekker Inc , New York, 1994.
6. B.D. Cullity - Elements of X-Ray Diffraction, 3<sup>rd</sup> edition, Prentice Hall , 2002.

<b>ME132</b>	<b>MANUFACTURING OF NON-METALLIC PRODUCTS</b>				
<b>(Program Elective-V)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>

			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:** After completion of the course student will be able to

- To understand the basic principles and manufacturing methods of polymers and rubber.
- To learn the applications and processing of glass and ceramics.
- To know the manufacturing and applications of composites.

**Course outcomes:** After completion of the course student will be able to

CO's	Description	Blooms Level
CO1	Describe the types of polymers and rubber and select their manufacturing techniques.	L2
CO2	Describe the application, types of glass and select its manufacturing methods.	L2
CO3	Describe the types of ceramics and select appropriate processing techniques.	L4
CO4	Knowledge in types of composites and their manufacturing techniques	L3
CO5	Describe the types of polymers and rubber and select their manufacturing techniques.	L2

### Program Articulation Matrix

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
<b>CO1</b>	3	2	2	2	
<b>CO2</b>	3	3	2	2	
<b>CO3</b>	3	3	2	2	
<b>CO4</b>	3	3	2	2	
<b>CO 5</b>	3	3	2	2	

### UNIT I

**Polymers** - classification - Thermoplastics and thermosetting plastics - Thermoforming processes - compression and transfer molding - injection molding - extrusion - blow molding - calendaring - lamination and pultrusion.

### UNIT II

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

**UNIT III**

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

**UNIT IV**

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

**UNIT V**

**Composites** - requirements of reinforcement and matrix - Manufacturing of composites - casting - solid state diffusion - cladding - HIP - liquid metal infiltration - liquid phase sintering - preparation of molding compounds and prepregs - hand layup method - autoclave method - filament winding method - compression molding - reaction injection molding - knitting - braiding.

**Suggested Readings:**

1. Ghosh, Polymer Science and Technology – Plastics, Rubber, Blends, and Composites, 2<sup>nd</sup> Edition, Tata-Mcgraw hill, 2001.
2. J.L.White, Rubber Processing Technology, Materials and Principles, Illustrated Edition, Hanser Publishers, 1995.
3. E. B. Shand, Glass Engineering Handbook, 2nd Edition, McGraw-Hill, 1958.
4. Kingery, w d &etc. Introduction to ceramics 2<sup>nd</sup>edition, John Wiley & Sons publishers, 2004.
5. ASM Handbook, Vol. 21 Composites, 2001 Lubin, Handbook of Composites, Springer,1st Edition, 1982.

<b>ME133</b>	<b>HIGH SPEED MACHINING</b>
<b>(Program Elective-V)</b>	

<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

**Course Objectives:**

- To emphasize the importance of advanced machining Processes.
- To study the appropriate cutting tools and materials for High speed machining
- To know the importance of dry and near dry machining
- To provide few practical applications of high speed machining

**Course outcomes:** After completion of the course student will be able to

<b>CO's</b>	<b>Description</b>	<b>Blooms Level</b>
CO1	Distinguish between conventional machining and high speed machining.	L2
CO2	Analyze the determinants of high speed machining and improve its performance.	L4
CO3	Evaluate the requirements on machine tool technology to support High Speed Machining	L3
CO4	Identify and Select the suitable cutting tool material for high speed machining.	L4
CO5	Estimate the impact of dry and near dry machining on environment	L3

**Program Articulation Matrix**

<b>Course outcome</b>	<b>Program outcome</b>				
	<b>PO1</b>	<b>PO2</b>	<b>PO3</b>	<b>PO4</b>	<b>PO5</b>
<b>CO1</b>	1	2	1		
<b>CO2</b>	3	3	3	2	1
<b>CO3</b>	3	3	3		1
<b>CO4</b>	3	3	3		1
<b>CO 5</b>	3	3	3	1	

**UNIT I**

Introduction: Advanced Machining Processes, A new Era.

**The Determinants of High-Speed Machining:** Weight, Materials, Machine Tools, Simple processes and Systems, Fast Machining, Response Time, and Throughput, Smart Machines, Tools, and Processes. **Characteristics of High-Speed Machining:** Machining Parameters.

**UNIT II**

**Machine-tool Technology:** Manufacturing and Multi-task Machining Systems, High-Speed Machining, Support Technology.

**UNIT III**

**Advanced Cutting Tools:** Cutting-Tool Materials, Cutting-Tool Design, Tool Guidance and Stability, Chip Control, Burr Control, Stringent Finish Requirements, Cost and Quality, Intelligent Tooling.

**UNIT IV**

**Precision Tooling Interface:** Connection and Interface, Tool Clamping, Balancing, Run-out.  
**Dry and Near-dry Machining:** Environmental Impact, Dry Machining, Near-dry Machining, Reducing Coolant Use.

**UNIT V**

**Practical Applications:** Precision Hard Machining, Machining Compacted Graphite Iron, Precision Roughing, Advanced Milling Operations, Machining with Multi-cut Tools.

**Suggested Reading:**

1. Bert P. Erdel, High Speed Machining, 1<sup>st</sup> Edition, SME Publications, Michigan, 2003
2. Dale Mickelson, Hard Milling and High Speed Machining, 1<sup>st</sup> Edition, Industrial Press Inc, United States, 2007.

(Program Elective-V)							
Pre-requisites				<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
				3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks		

**Course Objectives:**

- Understand strengthening mechanisms and testing methods like hardness, fracture, creep and fatigue in materials
- Comprehend the applications, properties and composition of various tool steels
- Understand the heat treatment of various tool steels, and specifications of die castings

**Course outcomes:** After completion of the course student will be able to

CO's	Description	Blooms Level
C01	Recognize strengthening mechanisms of metals and Categorize the behaviour of fracture, creep and fatigue in materials	L2
C02	Determining mechanical properties and understand the concepts of fracture analysis	L3
C03	Classify the tool and die steels and interpret the applications, properties and composition of various tool steels, modern cutting tool materials and plastics	L4
C04	Distinguish the requirements and specifications of ferrous and non ferrous die castings according to Bureau of Indian Standards(IS)	L3
C05	Assess the heat treatment of various types of tool steels.	L3

**Program Articulation Matrix**

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
<b>CO1</b>	3		1	2	2
<b>CO2</b>	3		1	3	2
<b>CO3</b>	3		2		
<b>CO4</b>	3		2		
<b>CO 5</b>	3		1	2	1

**UNIT-I:**

**Crystal Structure:** Types and Crystal Structures. Imperfections. Strain hardening, Plasticity range, Recovery, Recrystallisation and Grain growth. Mechanism of strengthening in metals. Grain size and its relation to mechanical properties.

**Failure of Materials:** ductile fracture, brittle fracture, fatigue, crack initiation and propagation, creep. Fatigue and Creep testing of materials.

**UNIT-II**

**Testing of Materials:** Review and brief discussion on stress strain diagram of steel and the parameters for ductility, toughness, tensile strength, percentage of elongation etc., True stress



and strain, Elastic Recovery After Plastic Deformation, Hardness, types of hardness measurements, comparison among hardness methods and scales. Fracture toughness testing. Failure analysis, Fractography.

### **UNIT-III**

**Tool and die steels:** Classification, selection and properties of tool steels. Effect of alloying elements in tool steels. Water-hardening tool steels, Shock-resisting tool steels, Cold work tool steels, Hot work tool steels, High speed tool steels, Mould steels and Special purpose tool steels. Types of modern Cutting Tool materials like Carbide, Coated carbides, Ceramics, CBN, Diamond, Sialons, Impregnated tools.

**Plastics** Properties of plastics-Thermo plastics-Thermo setting plastics. Methods of processing of plastics and plastic processing machines.

### **UNIT-IV**

**Ferrous and Non-ferrous Die castings:** Specifications, Properties and applications of Carbon and alloy Steels, Specification of Grey iron casting IS: 210 SG Cast Iron IS: 1865, Malleable iron castings IS: 14329. Selection and specification of die casting non-ferrous zinc (IS 713, IS742) and Aluminium (LM series).

**Powder Metallurgy:** Production of powders by various methods. Compacting, Sintering applications.

### **UNIT-V**

**Phase Diagrams:** Effect of alloying elements on Iron- Iron carbide equilibrium diagram. Isothermal Transformation diagrams. Microstructural and property changes in Iron-carbon alloys.

**Heat treatment:** Introduction and types, Hardenability. Heat treatment of Water-hardening tool steels, Shock-resisting tool steels, Cold work tool steels, Hot work tool steels, High speed tool steels. Case hardening methods. Heat treatment of non-ferrous materials.

### **Suggested Readings:**

1. William D Callister, Materials Science and Engineering an Introduction, 6<sup>th</sup> Edition, John Wiley & Sons, 2003.
2. Raghavan V., Materials Science and Engineering: A First Course, Prentice Hall, Fifth Edition, PHI , New Delhi, 2011.
3. Sidney H Avner, Introduction to Physical Metallurgy, 2<sup>nd</sup> Edition, McGraw Hill Book Company, 1974.
4. William E. Bryson, Heat Treatment, Selection, and Application of Tool Steels, 2<sup>nd</sup> edition, Hanser Publishers, 2009.
5. George Krauss, "Steels; Processes, Structure& Performance", ASM International, The Materials Information Society, 2005 IS Standards, BIS, New Delhi.

<b>OE 941 BM</b>	<b>MEDICAL ASSISTIVE DEVICES</b>				
<b>(OPEN ELECTIVE)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	To extend knowledge of the amputee, of lost and remaining functions affecting locomotion, and to collect information on the best possible medical treatment.
2	To improve fitting techniques and practices, including training, so that existing devices might be used with greater comfort and function.
3	To develop improved lower-extremity devices

<b>Course Outcomes:</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Apply fundamental knowledge of engineering in rehabilitation
<b>CO-2</b>	Apply analytical skills to assess and evaluate the need of the end-user
<b>CO-3</b>	Develop self-learning initiatives and integrate learned knowledge for problem solving
<b>CO-4</b>	Understand the basics of robotics and apply their principles in developing prosthetics
<b>CO-5</b>	Apply the knowledge of computers in solving rehabilitation problems

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

<b>Unit – I</b>
Introduction to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

<b>Unit – II</b>
Assistive Technology, Seating Biomechanics and systems. Wheeled Mobility: Categories of Wheelchairs. Wheelchair Structure and Component Design. Ergonomics of Wheel chair

propulsion. Power Wheelchair Electrical Systems. Control. Personal Transportation. Auxiliary devices and systems.

**Unit – III**

Sensory augmentation and substitution: Visual system: Visual augmentation. Tactual vision substitution, Auditory vision substitution; Auditory system: Auditory augmentation. Cochlear implantation, Visual auditory substitution, Tactual auditory substitution, Tactual system: Tactual augmentation. Tactual substitution. Measurement tools and processes: fundamental principles, structure, function; performance and behavior. Subjective and objective measurement methods.

**Unit – IV**

Rehabilitation Robotics, Major Limb Prosthetic Devices, Orthotic Devices, Types of orthotics and prosthetics, Intelligent prosthetic Knee, Prosthetic Hand, Controlled orthotics and prosthetics FES system, Restoration of Hand function, Restoration of standing and walking, Myo-electric Hand.

**Unit – V**

Augmentative and Alternative communication technology, Computer applications in Rehabilitation Engineering, telecommunications, and Web Accessibility.

**Suggested Reading:**

1	Robinson C.J., <i>Rehabilitation Engineering</i> , CRC Press, 1995.
2	Ballabio E., et al., <i>Rehabilitation Technology</i> , IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, <i>Series in medical physics and biomedical engineering: An introduction to rehabilitation engineering</i> , Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino <i>The biomedical engineering handbook -biomedical engineering fundamentals</i> , 3 <sup>rd</sup> Ed., CRC Press, Taylor & Francis Group, London, 2006.

<b>OE 942 BM</b>	<b>MEDICAL IMAGING TECHNIQUES</b>				
<b>(OPEN ELECTIVE)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the students with various medical imaging modalities.
2	To make learners understand the principles, detectors and operating procedures of X-ray, CT, MRI, ultrasound, PET and SPECT.
3	To make the students learn the advantages, disadvantages and hazards of various medical imaging equipment.

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Interpret the working principle and operating procedure and applications of X-ray equipment.
<b>CO-2</b>	Understand the image reconstruction techniques and applications of CT.
<b>CO-3</b>	Summarize the image acquisition and reconstruction techniques in MRI.
<b>CO-4</b>	Comprehend the working principle, modes and medical applications of ultrasound imaging.
<b>CO-5</b>	Examine the operation and applications of PET, SPECT and radio nuclide instrumentation.

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

<b>Unit – I</b>
<b>X ray Imaging:</b> Electromagnetic spectrum, Production of X-rays, X-ray tubes- Stationary and Rotating Anode types, Block diagram of an X-Ray Machine, Collimators and Grids, Timing and Exposure controls. X-Ray Image visualization-Films, Fluorescent screens, Image Intensifiers.
Dental X-Ray machines, Portable and mobile X-Ray units, Mammographic X-Ray equipment, Digital Radiography and flat panel detectors.

Radiation safety, ALARA principle, Dose units and dose limits, Radiation dosimeters and detectors.

**Unit – II**

**Computed Tomography:** Basic principles, CT number scale, CT Generations. Major sub systems- Scanning system, processing unit, viewing unit, storage unit. Need and Principle of sectional imaging, 2D image reconstruction techniques - Iteration and Fourier methods. Applications of CT - Angio, Osteo, Dental, Perfusion (Body & Neuro), Virtual Endoscopy, Coronary Angiography.

**Unit – III**

**Magnetic Resonance Imaging:** Principles of NMR imaging systems, Image reconstruction techniques-Relaxation processes, imaging/ pulse sequences. Sub systems of an NMR imaging system, NMR detection system, types of coils, biological effects and advantages of NMR imaging.

Functional MRI - The BOLD effect, intra and extra vascular field offsets, source of T2\* effects, Creating BOLD contrast sequence optimization sources and dependences of physiological noise in fMRI.

**Unit – IV**

**Ultrasound Imaging:** - Principles of image formation -Imaging principles and instrumentation of A-mode, B-Mode, Gating Mode, Transmission mode and M-mode. Basics of multi-element linear array scanners, Digital scan conversion.

Doppler Ultrasound and Colour Doppler imaging, Image artifacts, Biological effects, Ultrasound applications in diagnosis, therapy and surgery.

**Unit – V**

**Nuclear Medicine**–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation detectors, Pulse height analyzer, Rectilinear scanner, Gamma camera.

Emission Computed Tomography (ECT), Principle and instrumentation of Single Photon Emission Computed Tomography(SPECT) and Positron Emission Tomography (PET). Comparison of SPECT, PET and combined PET/ X-ray CT.

**Suggested Reading:**

1	Khandpur R.S., <i>Handbook of Biomedical Instrumentation</i> , Tata McGraw Hill, 2016.
2	S Webb, " <i>The Physics of Medical Imaging</i> ", Adam Highler, Bristol Published by CRC Press, 1988.
3	A C Kak, " <i>Principle of Computed Tomography</i> ", IEEE Press New York, 1988.
4	Hykes, Heorick, Starchman, <i>Ultrasound physics and Instrumentation</i> MOSBY year book, 2 <sup>nd</sup> Ed. 1992.
5	Stewart C.Bushong, <i>Magnetic Resonance Imaging- physical and biological principles</i> , MOSBY, 2 <sup>nd</sup> Ed., 1995.

<b>OE 941 CE</b>	<b>GREEN BUILDING TECHNOLOGY</b>				
<b>(OPEN ELECTIVE)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	Exposure to the green building technologies and their significance.
2	Understand the judicious use of energy and its management.
3	Educate about the Sun-earth relationship and its effect on climate.
4	Enhance awareness of end-use energy requirements in the society.
5	Develop suitable technologies for energy management

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Understand the fundamentals of energy use and energy processes in building.
<b>CO-2</b>	Identify the energy requirement and its management.
<b>CO-3</b>	Know the Sun-earth relationship vis-a-vis its effect on climate.
<b>CO-4</b>	Be acquainted with the end-use energy requirements.
<b>CO-5</b>	Be familiar with the audit procedures of energy

<b>Course outcome</b>	<b>Program Outcome</b>					
	<b>PO-1</b>	<b>PO-2</b>	<b>PO-3</b>	<b>PO-4</b>	<b>PO-5</b>	<b>PO-6</b>
<b>CO-1</b>	3	3	3	2	1	2
<b>CO-2</b>	3	2	3	2	1	1
<b>CO-3</b>	3	2	3	2	1	2
<b>CO-4</b>	3	2	3	2	1	2
<b>CO-5</b>	3	2	3	2	1	1

<b>Unit – I</b>
Overview of the significance of energy use and energy processes in building - Indoor activities and environmental control - Internal and external factors on energy use and the attributes of the factors - Characteristics of energy use and its management - Macro aspect of energy use in dwellings and its implications.

<b>Unit – II</b>
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Indoor environmental requirement and management - Thermal comfort - Ventilation and air quality – Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement.

**Unit – III**

Climate, solar radiation and their influences - Sun-earth relationship and the energy balance on the earth's surface - Climate, wind, solar radiation, and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings.

**Unit – IV**

End-use, energy utilization and requirements - Lighting and day lighting - End-use energy requirements - Status of energy use in buildings Estimation of energy use in a building. Heat gain and thermal performance of building envelope - Steady and non-steady heat transfer through the glazed window and the wall - Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

**Unit – V**

**Nuclear Medicine**–Radioisotopes in medical diagnosis, Basic instrumentation- Radiation Energy management options - Energy audit and energy targeting - Technological options for energy management.

**Suggested Reading:**

1	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.
2	Carter, W. Nick, (1991): Disaster Management, Asian Development Bank, Manila.
3	Sahni, Pardeep et.al. (eds.) (2002), Disaster Mitigation Experiences and Reflections, Prentice Hall of India, New Delhi.
4	Bryant Edwards (2005): Natural Hazards, Cambridge University Press, U.K.

<b>OE 942 CE</b>	<b>COST MANAGEMENT OF ENGINEERING PROJECTS</b>				
<b>(OPEN ELECTIVE)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	Introduce the concepts of cost management
2	Fundamentals of cost overruns
3	Introduce the concepts of Quantitative techniques for cost management Linear Programming, PERT/CPM.

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Understanding of strategic cost management process, control of cost and decision making based on the cost of the project.
<b>CO-2</b>	Ability to appreciate detailed engineering activities of the project and execution of projects
<b>CO-3</b>	Preparation of project report and network diagram
<b>CO-4</b>	Able to plan Cost Behavior , Profit Planning , Enterprise Resource Planning, Total Quality Management.
<b>CO-5</b>	Applications of various quantitative techniques for cost management

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

<b>Unit – I</b>
Introduction and Overview of the Strategic Cost Management Process-Cost concepts in decision-making; relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System- Inventory valuation- Creation of a Database for operational control; Provision of data for Decision-Making.

<b>Unit – II</b>
Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning- Project execution as conglomeration of technical and non- technical activities- Detailed Engineering activities.

<b>Unit – III</b>
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Pre project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process.

**Unit – IV**

Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems- Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector- Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints- Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets- Performance budgets- Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing.

**Unit – V**

Quantitative techniques for cost management, Linear Programming, PERT/CPM,- Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

**Suggested Reading:**

1	Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2	Charles T. Horngren and George Foster, Advanced Management Accounting
3	Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4	Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5	N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co.Ltd.

<b>OE 941 CS</b>	<b>BUSINESS ANALYTICS</b>				
<b>(OPEN ELECTIVE)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	Understanding the basic concepts of business analytics and applications
2	Study various business analytics methods including predictive, prescriptive and prescriptive analytics
3	Prepare the students to model business data using various data mining, decision making methods

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	To understand the basic concepts of business analytics
<b>CO-2</b>	Identify the application of business analytics and use tools to analyze business data
<b>CO-3</b>	Become familiar with various metrics, measures used in business analytics
<b>CO-4</b>	Illustrate various descriptive, predictive and prescriptive methods and techniques
<b>CO-5</b>	Model the business data using various business analytical methods and techniques

<b>Course outcome</b>	<b>Program Outcome</b>					
	<b>PO-1</b>	<b>PO-2</b>	<b>PO-3</b>	<b>PO-4</b>	<b>PO-5</b>	<b>PO-6</b>
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

<b>Unit – I</b>
<b>Introduction to Business Analytics:</b> Introduction to Business Analytics, need and science of data driven (DD) decision making, Descriptive, predictive, prescriptive analytics and techniques, Big data analytics, Web and Social media analytics, Machine Learning algorithms, framework for decision making, challenges in DD decision making and future.

**Unit – II**

**Descriptive Analytics:** Introduction, data types and scales, types of measurement scales, population and samples, measures of central tendency, percentile, decile and quadrille, measures of variation, measures of shape-skewness, data visualization.

**Unit – III**

**Forecasting Techniques:** Introduction, time-series data and components, forecasting accuracy, moving average method, single exponential smoothing, Holt’s method, Holt-Winter model, Croston’s forecasting method, regression model for forecasting, Auto regression models, auto-regressive moving process, ARIMA, Theil’s coefficient

**Unit – IV**

**Decision Trees:** CHAID, Classification and Regression tree, splitting criteria, Ensemble and method and random forest. **Clustering:** Distance and similarity measures used in clustering, Clustering algorithms, K-Means and Hierarchical algorithms, **Prescriptive Analytics-** Linear Programming (LP) and LP model building.

**Unit – V**

**Six Sigma:** Introduction, introduction, origin, 3-Sigma Vs Six-Sigma process, cost of poor quality, sigma score, industry applications, six sigma measures, DPMO, yield, sigma score, DMAIC methodology, Six Sigma toolbox.

**Suggested Reading:**

1	U Dinesh Kumar, “Data Analytics”, Wiley Publications, 1st Edition, 2017
2	Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, “Business analytics Principles, Concepts, and Applications with SAS”, Associate Publishers, 2015
3	S. Christian Albright, Wayne L. Winston, “Business Analytics - Data Analysis and Decision Making”, 5th Edition, Cengage, 2015

**Web Resources:**

1	<a href="https://onlinecourses.nptel.ac.in/noc18-mg11/preview">https://onlinecourses.nptel.ac.in/noc18-mg11/preview</a>
2	<a href="https://nptel.ac.in/courses/110105089/">https://nptel.ac.in/courses/110105089/</a>

<b>OE 941 EC</b>	<b>ELEMENTS OF EMBEDDED SYSTEMS</b>					
<b>(OPEN ELECTIVE)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	Understanding various Embedded Design strategies
2	Designing Micro controller based Embedded Systems
3	Designing FPGA Based Embedded Systems

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Understand Embedded Design Strategies and architecture of Arduino Board
<b>CO-2</b>	Program using various onboard components of Arduino
<b>CO-3</b>	Design real time interfacing with Arduino
<b>CO-4</b>	Understand Design Flow of FPGA, programming FPGA using Verilog HDL
<b>CO-5</b>	Implement combinational and sequential circuits using verilog HDL

<b>Course outcome</b>	<b>Program Outcome</b>					
	<b>PO-1</b>	<b>PO-2</b>	<b>PO-3</b>	<b>PO-4</b>	<b>PO-5</b>	<b>PO-6</b>
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

<b>Unit – I</b>
<b>Embedded Systems Design Strategies:</b> Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

<b>Unit – II</b>
<b>Interfacing:</b> Interfacing Switches, LEDs, Analog to Digital Converter, Digital to Analog Converter, Interfacing and Programming I2C, SPI

<b>Unit – III</b>
<b>Real Time Programming:</b> Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors, Interfacing Stepper Motor, USB programming

<b>Unit – IV</b>
<b>FPGA Based Embedded Design:</b> FPGA Design flow, Introduction to Verilog HDL, Basic building blocks, Data types of Verilog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchical Structural Modelling, Case Studies on Verilog HDL descriptions of Basic Circuits

**Unit – V**

**Modelling of Circuits:** Verilog HDL Implementation of Combinational MSI Circuits, Verilog HDL Implementation of Sequential MSI Circuits, Finite State Machine Design, Tasks and Functions, Introduction to Test Benches

**Suggested Reading:**

1	Ming-Bo Lin, Digital System Designs and Practices Using Verilog HDL and FPGAs, Wiley India, 2008
2	Samir Palnitkar, Verilog HDL: A Guide to Digital Design and Synthesis, Pearson Education, 2005
3	Simon Monk, Programming Arduino: Getting Started with sketches, Mc.Hill, 2016

**Web Resources:**

1	<a href="http://www.arduino.cc">www.arduino.cc</a>
2	<a href="http://www.learn.sparkfun.com/tutorials/arduino">www.learn.sparkfun.com/tutorials/arduino</a>

<b>OE 941 EE</b>	<b>WASTE TO ENERGY</b>				
<b>(OPEN ELECTIVE)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	To know the various forms of waste
2	To understand the processes of Biomass Pyrolysis.
3	To learn the technique of Biomass Combustion.

<b>Course Outcomes:</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Understand the concept of conservation of waste
<b>CO-2</b>	Identify the different forms of wastage.
<b>CO-3</b>	Chose the best way for conservation to produce energy from waste.
<b>CO-4</b>	Explore the ways and means of combustion of biomass.
<b>CO-5</b>	Develop a healthy environment for the mankind.

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>	3	-	3	2	3	1
<b>CO-2</b>	3	-	3	2	3	1
<b>CO-3</b>	3	-	3	2	3	1
<b>CO-4</b>	3	-	3	2	3	1
<b>CO-5</b>	3	-	3	2	3	1

<b>Unit – I</b>
<b>Introduction to Energy from Waste:</b> Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

<b>Unit – II</b>
<b>Biomass Pyrolysis:</b> Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

<b>Unit – III</b>
<b>Biomass Gasification:</b> Gasifiers – Fixed bed system – Downdraft and updraft gasifiers Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**Unit – IV**

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

**Unit – V**

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

**Suggested Reading:**

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

<b>OE 942 EE</b>	<b>POWER PLANT CONTROL AND INSTRUMENTATION</b>					
<b>(OPEN ELECTIVE)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	The operation of different types of power plants.
2	The basic working principle of instruments for measurement of electrical and non-electrical quantities like Temperature Pressure flow level measurements.
3	The instrumentation and protection systems applied in thermal power plant.
4	The control techniques employed for the operation of modern power generation plant

<b>Course Outcomes:</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Explain the different methods of power generation. Along with Piping and Instrumentation diagram of boiler.
<b>CO-2</b>	Select various measurements involved in power generation for measuring electrical and non-electrical parameters.
<b>CO-3</b>	Identify the different types of analyzers used for scrutinizing boiler steam and water.
<b>CO-4</b>	Model different types of controls and control loops in boilers.
<b>CO-5</b>	Illustrate the methods of monitoring and control of different parameters like speed, vibration of turbines

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>	3	1	-	-	-	2
<b>CO-2</b>	3	1	-	-	-	2
<b>CO-3</b>	3	1	-	-	-	2
<b>CO-4</b>	3	1	-	-	-	2
<b>CO-5</b>	3	1	-	-	-	2

<b>Unit – I</b>
Brief survey of methods of power generation, hydro, thermal, nuclear, solar and wind power, importance of instrumentation in power generation, thermal power plants, block diagram, details of boiler processes, Piping and Instrumentation diagram of boiler, cogeneration.



**Unit – II**

Electrical measurements, current, voltage, power, frequency, power factor etc, non-electrical parameters, flow of feed water, fuel, air and steam with correction factor for temperature, steam pressure and steam temperature, drum level measurement, radiation detector, smoke density measurement, dust monitor.

**Unit – III**

Flue gas oxygen analyzer: Analysis of impurities in feed water and steam, dissolved oxygen analyzer. Chromatography, pH meter, fuel analyzer, pollution monitoring instruments.

**Unit – IV**

Combustion control, air / fuel ratio control, furnace draft control, drum level control, main steam and reheat steam temperature control, super heater control, air temperature, distributed control system in power plants, interlocks in boiler operation.

**Unit – V**

Speed, vibration, shell temperature monitoring and control, steam pressure control, lubricant oil temperature control, cooling system.

**Suggested Reading:**

1	Sam G. Dukelow, The Control of Boilers, Instrument Society of America, 2nd Edition, 2010.
2	P.K. Nag, „Power Plant Engineering“, Tata McGraw-Hill, 1st Edition, 2001.
3	S.M. Elonka and A.L. Kohal, “Standard Boiler Operations”, Tata McGraw-Hill, 1st Edition, 1994.
4	R K Jain, “Mechanical and Industrial Measurements”, Khanna Publishers, 1st Edition, 1995.
5	E Al Wakil, “Power Plant Engineering”, Tata McGraw-Hill, 1st Edition, 1984.

<b>OE 941 ME</b>	<b>OPERATION RESEARCH</b>						
<b>(OPEN ELECTIVE)</b>							
<b>Pre-requisites</b>				<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
				3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks		

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	To understand the dynamic programming to solve problems of discrete and continuous variables
2	To apply the concept of non-linear programming and carry out sensitivity analysis
3	To understand deterministic and probabilistic inventory control models.

<b>Course Outcomes:</b>	
After the completion of this course, the students shall be able to:	
<b>CO-1</b>	To understand the basics of OR, including mathematical modeling, feasible solutions and optimization.
<b>CO-2</b>	Able to carry out sensitivity analysis.
<b>CO-3</b>	Apply PERT/CPM in project management.
<b>CO-4</b>	Select appropriate inventory control model.
<b>CO-5</b>	Able to apply dynamic programming and understand the concept of non-linear programming.

<b>Course Outcome</b>	<b>Program Outcome</b>					
	<b>PO-1</b>	<b>PO-2</b>	<b>PO-3</b>	<b>PO-4</b>	<b>PO-5</b>	<b>PO-6</b>
<b>CO-1</b>	1	1	3	2	1	2
<b>CO-2</b>	3	1	2	3	2	-
<b>CO-3</b>	1	3	3	1	2	2
<b>CO-4</b>	3	2	1	3	1	1
<b>CO-5</b>	2	1	3	2	2	2

<b>Unit - I</b>
Development, Different Phases, Characteristics, Operations Research models and applications. Linear Programming Problem: Introduction, Basic Assumptions, Formulation, graphical method, simplex method: Big M and Two Phase method.

<b>Unit - II</b>
<b>DUALITY:</b> Duality theory, primal-dual relationships, Economic interpretation, Dual simplex method, Post optimal or sensitivity analysis.

<b>Unit - III</b>
<b>Project Management:</b> Introduction to PERT and CPM, critical Path calculation, float calculation and its importance. Cost reduction by Crashing of activity. <b>Inventory models</b> – Economic order quantity models – Quantity discount models – Stochastic inventory models – Multi product models – Inventory control models in practice.

<b>Unit - IV</b>
<b>Sequencing Models:</b> Introduction, General assumptions, processing n jobs through 2 machines, processing 'n' jobs through m machines.
<b>Game Theory:</b> Introduction, Characteristics of Game Theory, Dominance theory, Mixed strategies (2 x 2, m x 2), Algebraic and graphical methods.
<b>Nonlinear programming problem:</b> - Kuhn-Tucker conditions.

<b>Unit - V</b>
<b>Queuing models</b> - Queuing systems and structures – Notation parameter – Single server and multi server models – Poisson arrivals – Exponential service times – with finite population – Infinite population. Dynamic Programming: Characteristics, principle of optimality, deterministic problems.

**Suggested Reading:**

1	H.A. Taha, Operations Research, An Introduction, PHI, 2008
2	H.M. Wagner, Principles of Operations Research, PHI, Delhi, 2010
3	J.C. Pant, Introduction to Optimization: Operations Research, Jain Brothers, Delhi, 2008.
4	Frederick S. Hillier, Gerald J. Lieberman, Operations Research, 10th Edition, McGraw Hill Pub. 2017.
5	Panner selvam, Operations Research: Prentice Hall of India, 2010.
6	Ronald L. Rardin, Optimization in Operations Research, First Indian Reprint, Pearson Education Asia. 2002,

<b>OE 942 ME</b>	<b>COMPOSITE MATERIALS</b>				
	<b>(OPEN ELECTIVE)</b>				
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>Study the concepts of composite construction.</i>
2	<i>Learn analysis and designs of composite beams, floors, columns and trusses as per the recommendations of IS codes of practice.</i>
3	<i>Apply the concepts for design of multi-storey composite buildings.</i>
4	<i>Scope of analysis is restricted to skeletal structures subjected to prescribed dynamic loads.</i>

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Understand the fundamentals of composite construction, and analysis and designs of composite beams.</i>
<b>CO-2</b>	<i>Analyse and design the composite floors</i>
<b>CO-3</b>	<i>Select suitable materials for composite columns,</i>
<b>CO-4</b>	<i>Analyse composite trusses and understand connection details.</i>
<b>CO-5</b>	<i>Analyse and design the multi-storey composite buildings</i>

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	2	1	3	2	1	1
CO-2	3	2	1	1	2	-
CO-3	2	2	2	3	2	1
CO-4	1	3	1	2	1	1
CO-5	1	1	2	3	2	3

### Unit – I

Introduction of composite constructions: Benefits of composite construction - Introduction to IS - BS and Euro codal provisions.

Composite beams: Elastic behaviour of composite beams - No and full interaction cases - Shear connectors - Ultimate load behaviour - Serviceability limits - Effective breadth of flange - Interaction between shear and moment - Basic design consideration and design of composite beams.

### Unit – II

Composite floors: Structural elements - Profiled sheet decking - Bending resistance - Shear resistance - Serviceability criterion - Analysis for internal forces and moments - Design of composite floors.

### Unit – III

Composite columns: Materials - Concrete filled circular tubular sections - non-dimensional slenderness - Local buckling of steel sections - Effective elastic flexural stiffness - Resistance of members to axial compressions - Composite column design - Fire resistance.

### Unit – IV

Composite trusses: Design of truss - Configuration - Truss members - Analysis and design of composite trusses and connection details.

### Unit – V

Design of multi-storey composite buildings: Design basis - Load calculations - Design of composite slabs with profile decks - Composite beam design - Design for compression members - Vertical cross bracings - Design of foundation.

### Suggested Reading:

1	R.P. Johnson, "Composite Structures of Steel and Concrete - Beams, Slabs, Columns and Frames in Buildings", Blackwell Publishing, Malden, USA, 2004.
2	"INSDAG Teaching Resources for Structural Steel Design", Vol-2, Institute for Steel Development and Growth Publishers, Calcutta, India.
3	"INSDAG Handbook on Composite Construction – Multi-Storey Buildings", Institute for Steel Development and Growth Publishers, Calcutta, India.
4	"INSDAG Design of Composite Truss for Building", Institute for Steel Development and Growth Publishers, Calcutta, India.
5	"INSDAG Handbook on Composite Construction – Bridges and Flyovers", Institute for Steel Development and Growth Publishers, Calcutta, India.
6	IS: 11384-1985, "Code of Practice for Composite Construction in Structural Steel and Concrete", Bureau of Indian Standards, New Delhi, 1985.

<b>OE943 ME</b>	<b>INDUSTRIAL SAFETY</b>					
<b>(OPEN ELECTIVE)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	Causes for industrial accidents and preventive steps to be taken.
2	Fundamental concepts of Maintenance Engineering.
3	About wear and corrosion along with preventive steps to be taken
4	The basic concepts and importance of fault tracing.
5	The steps involved in carrying out periodic and preventive maintenance of various equipments used in industry

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Identify the causes for industrial accidents and suggest preventive measures.
<b>CO-2</b>	Identify the basic tools and requirements of different maintenance procedures.
<b>CO-3</b>	Apply different techniques to reduce and prevent Wear and corrosion in Industry.
<b>CO-4</b>	Identify different types of faults present in various equipments like machine tools, IC Engines, boilers etc.
<b>CO-5</b>	Apply periodic and preventive maintenance techniques as required for industrial equipments like motors, pumps and air compressors and machine tools etc

<b>Course outcome</b>	<b>Program Outcome</b>					
	<b>PO-1</b>	<b>PO-2</b>	<b>PO-3</b>	<b>PO-4</b>	<b>PO-5</b>	<b>PO-6</b>
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

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

**Unit – II**

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

**Unit – III**

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

**Unit – IV**

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

**Unit – V**

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

**Suggested Reading:**

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

<b>OE 941 LA</b>	<b>INTELLECTUAL PROPERTY RIGHTS</b>					
<b>(OPEN ELECTIVE)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			3	-	-	3
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	Acquaint the students with basics of intellectual property rights with special reference to Indian Laws and its practices.
2	Compare and contrast the different forms of intellectual property protection in terms of their key differences and similarities.
3	Provide an overview of the statutory, procedural, and case law underlining these processes and their interplay with litigation.

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Understand the concept of intellectual property rights.
<b>CO-2</b>	Develop proficiency in trademarks and acquisition of trade mark rights.
<b>CO-3</b>	Understand the skill of acquiring the copy rights, ownership rights and transfer.
<b>CO-4</b>	Able to protect trade secrets, liability for misappropriations of trade secrets.
<b>CO-5</b>	Apply the patents and demonstration of case studies.

<b>Course outcome</b>	<b>Program Outcome</b>					
	<b>PO-1</b>	<b>PO-2</b>	<b>PO-3</b>	<b>PO-4</b>	<b>PO-5</b>	<b>PO-6</b>
<b>CO-1</b>	2	1	3	2	1	1
<b>CO-2</b>	3	2	1	1	2	-
<b>CO-3</b>	2	2	2	3	2	1
<b>CO-4</b>	1	3	1	2	1	1
<b>CO-5</b>	1	1	2	3	2	3

<b>Unit – I</b>
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.

<b>Unit – II</b>
Trade Marks: Purpose and function of trademarks, acquisition of trade mark rights, protectable matter, selecting, and evaluating trade mark, trade mark registration

processes.

**Unit – III**

Law of copy rights: Fundamental of copy right law, originality of material, rights of reproduction, rights to perform the work publicly, copy right ownership issues, copy right registration, notice of copy right, international copy right law. Law of patents: Foundation of patent law, patent searching process, ownership rights and transfer.

**Unit – IV**

Trade Secrets: Trade secrete law, determination of trade secrete status, liability for misappropriations of trade secrets, protection for submission, trade secrete litigation. Unfair competition: Misappropriation right of publicity, false advertising.

**Unit – V**

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

**Suggested Reading:**

1	Halbert, “Resisting Intellectual Property”, Taylor & Francis Ltd, 2007.
2	Mayall, “Industrial Design”, McGraw Hill,1992
3	Niebel, “Product Design”, McGraw Hill,1974.
4	Asimov, “Introduction to Design”, Prentice Hall,1962.
5	Robert P. Merges, Peter S. Menell, Mark A. Lemley, “Intellectual Property in New Technological Age”,2016.
6	T. Ramappa, “Intellectual Property Rights Under WTO”, S. Chand,2008



MC070	MINI PROJECT					
Pre-requisites	-		L	T	P	C
			-	-	4	2
Evaluation	SEE	-	CIE	50 Marks		

**Course Objectives:**

- Understand the purpose of doing mini project
- Learn the resources available at the college and outside for pursuing project
- Importance of literature review
- Learn to select appropriate software and procedure
- Learn to document results and arrive at required conclusions

**Course Outcomes:** At the end of the course, the student will be able to:

1. Identify engineering problems reviewing available literature
2. Study different techniques used to analyze complex systems.
3. Use related techniques and software's for solving the problem
4. Interpret the results and arrive at the relevant conclusions.
5. Document the findings as a technical report with proper references

**Guidelines**

1. Guide allocation will be done at the beginning of the semester. Identification of will be done with Guides consultation
2. Mini project presentation should be done along with the report on identification of topic for the work and the methodology adopted involving scientific research, collection and analysis of data, determining solutions highlighting individuals' contribution.
3. Evaluation of Mini project will be done by the Departmental Committee. Half of the marks are awarded by the Guide and the remaining half of the marks will be awarded by Departmental Committee.

<b>ME 152</b>	<b>COMPUTATIONAL LABORATORY FOR PE</b>					
<b>Pre-requisites</b>	-		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			-	-	2	1
<b>Evaluation</b>	<b>SEE</b>	-	<b>CIE</b>	50		

**Course Objectives:**

- Understanding the MATLAB environment
- To introduce to the software MATLAB for numerical computations
- Carry out simple numerical computations and analyses using MATLAB
- Able to implement matlab and SIMULINK for real time projects
- Introduce Genetic Algorithms, PSO, ANN for production Engineering applications

**Course Outcomes:** After completion of the course student will be able to

1. Ability to perform simulations/ experiment and understand the phenomenon
2. Critically evaluate and interpret the results
3. Prepare a well-organized record

**MATLAB programs**

1. Introduction to MATLAB
2. Evaluate the mathematical expressions in Matlab
3. Write scripts and functions to make single-index arrays
4. Basic syntax and command-line exercises, Basic array exercises, Relational and logical operations
5. Matrices operators
6. Control of flow: if-blocks , Loop constructs: for and while
7. Problems on generating various kinds of 2D & 3D Plots
8. Solving ordinary differential equations
9. Solving non-linear algebraic equations
10. Applications of Curve fitting and interpolation
11. Usage of Data Analysis and statistics
12. Introduction to optimization methods like Genetic Algorithms, Fuzzy, Neural & PSO
13. Simulink applied to manufacturing processes

<b>ME 153</b>	<b>MANUFACTURING SIMULATION LAB</b>					
<b>Pre-requisites</b>	-		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			-	-	2	1
<b>Evaluation</b>	<b>SEE</b>	-	<b>CIE</b>	50		

**Course Objectives:**

- Simulate the deformation, stress distribution of simple configurations
- Analyze the mold flow and solidification process in casting
- Model and analyze the formed and welded components
- Write manual part program & generate tool path for turning and Milling operation

**Course Outcomes:** After completion of the course student will be able to

1. Ability to perform simulations/ experiment and understand the phenomenon
2. Critically evaluate and interpret the results
3. Prepare a well-organized record

**List of Experiments:**

**Modeling & simulation**

1. Introduction to Finite Element Analysis Software.
2. Static Analysis of a corner bracket.
3. Determination of Beam stresses and Deflection.
4. Analysis of cylindrical shell under pressure.
5. Thermal mixed boundary problem
6. Transient Heat transfer in an infinite slab.
7. Stress analysis in a long cylinder.
8. Mold flow analysis of casting
9. Solidification of a casting.
10. Simulation of welded joint
11. Modeling and simulation of extruded, rolled and forged component

**Manufacturing:**

12. Manual part programming & tool path simulation for CNC turning and milling
13. Generation of part program, using CAPS turn and CAPS mill
14. Simulation of plant layout using Flexim software
15. Modelling of a simple component, stl file generation and estimating built time by varying various process parameters.

**SEMESTER-III**

<b>AC030 ME</b>	<b>RESEARCH METHODOLOGY IN MECHANICAL ENGINEERING</b>					
<b>AUDIT - I</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
1	Learn to focus on research related activities.
2	Learn methods to devise and develop the various research designs
3	Learn basic principles of data collection and analysis techniques
4	Learn the style and format of writing a report for technical papers

<b>Course Outcomes :</b> After completion of the course student will be able to	
<b>CO-1</b>	Motivate the orientation towards research related activities
<b>CO-2</b>	Formulate the research problem, analyze research related information
<b>CO-3</b>	Identify various sources for literature review and design an experimentation set-up
<b>CO-4</b>	Apply the basic principles of data collection and analysis techniques
<b>CO-5</b>	Improve the style and format of writing a report for technical / Journal articles

<b>UNIT – I</b>
<p><b>Research Methodology:</b> Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Research and Scientific Method, Important of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general.</p> <p><b>Defining the Research Problem:</b> Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem</p>

<b>UNIT – II</b>
<p><b>Literature Survey:</b> Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. <b>Literature Review:</b> Need of Review, Guidelines for Review, Record of Research Review.</p>

**UNIT – III**

**Research Design:** Meaning of Research Design, Need of Research Design, Feature of a Good Design Important Concepts Related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

**UNIT – IV**

**Data Collection:** Collection of primary data, Secondary data, Data organization, Methods of data grouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Need for sampling, some important sampling definitions, Estimation of population, Role of Statistics for Data Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of central tendency and Dispersion, Hypothesis testing, Use of Statistical software.

**Data Analysis:** Deterministic and random data, Uncertainty analysis, Tests for significance: Chi-square, student's t-test, Regression modeling, Direct and Interaction effects, ANOVA, F-test, Time Series analysis, Autocorrelation and Autoregressive modeling

**UNIT – V**

**Research Report Writing:** Format of the Research report, Synopsis, Dissertation, Thesis its Differentiation, References/Bibliography/Webliography, Technical paper writing/Journal report writing, making presentation, Use of visual aids. **Research Proposal Preparation:** Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

**Suggested Reading:**

1	C.R Kothari, Research Methodology, Methods & Technique; Revised Edition, New Age International Publishers, 2004
2	R. Ganesan, Research Methodology for Engineers, 1 <sup>st</sup> Edition, MJP Publishers, 2011.
3	Ratan Khananabis and Suvasis Saha, Research Methodology, 1 <sup>st</sup> Edition, Universities Press, Hyderabad, 2015
4	Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, 1 <sup>st</sup> Edition, Sterling Publs., Pvt., Ltd., New Delhi, 2004
5	Vijay Upagade and Aravind Shende, Research Methodology, 1 <sup>st</sup> Edition, S. Chand & Company Ltd., New Delhi, 2009
6	G. Nageswara Rao, Research Methodology and Quantitative methods, 2 <sup>nd</sup> Edition, BS Publications, Hyderabad, 2012.

<b>AC 031</b>	<b>ENGLISH FOR RESEARCH PAPER WRITING</b>				
<b>(AUDIT COURSE - II)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>Understand that how to improve your writing skills and level of readability</i>
2	<i>Understand the nuances of language and vocabulary in writing a Research Paper.</i>
3	<i>Develop the content, structure, format of writing a research paper and produce original research papers without plagiarism</i>

<b>Course Outcomes:</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Interpret the nuances of research paper writing.</i>
<b>CO-2</b>	<i>Differentiate the research paper format and citation of sources.</i>
<b>CO-3</b>	<i>To review the research papers and articles in a scientific manner.</i>
<b>CO-4</b>	<i>Avoid plagiarism and be able to develop their writing skills in presenting the research work.</i>
<b>CO-5</b>	<i>Create a research paper and acquire the knowledge of how and where to publish their original research papers</i>

<b>Unit – I</b>
<i>Academic Writing: Meaning &amp; Definition of a research paper– Purpose of a research paper – Scope – Benefits, Limitations – outcomes.</i>

<b>Unit – II</b>
<i>Research Paper Format: Title – Abstract – Introduction – Discussion – Findings, Conclusion – Style of Indentation – Font size/Font types – Indexing – Citation of sources.</i>

<b>Unit – III</b>
<i>Research Methodology: Methods (Qualitative – Quantitative) Review of Literature. Criticizing, Paraphrasing &amp; Plagiarism.</i>

<b>Unit – IV</b>
<i>Process of Writing a research paper: Choosing a topic - Thesis Statement – Outline – Organizing notes - Language of Research – Word order, Paragraphs – Writing first draft – Revising/Editing - The final draft and proof reading.</i>

**Unit – V**

*Research Paper Publication:* Reputed Journals – National/International – ISSN No, No. of volumes, Scopus Index/UGC Journals – Free publications - Paid Journal publications – Advantages/Benefits

*Presentation Skills:* Developing Persuasive Presentations, Structure of Presentation, Presentation Slides, Presentation Delivery, role of the audience, what to search and cite, how to establish credibility.

**Suggested Reading:**

1	C. R Kothari, Gaurav, Garg, “ <i>Research Methodology Methods and Techniques</i> ”, 4/e, New Age International Publishers.
2	Day R, “ <i>How to Write and Publish a Scientific Paper</i> ”, Cambridge University Press, 2006
3	“ <i>MLA Hand book for writers of Research Papers</i> ”, 7/e, East West Press Pvt. Ltd, New Delhi
4	Lauri Rozakis, Schaum’s, “ <i>Quick Guide to Writing Great Research Papers</i> ”, Tata McGraw Hills Pvt. Ltd, New Delhi.

<b>AC 032</b>	<b>DISASTER MITIGATION AND MANAGEMENT</b>					
<b>(AUDIT COURSE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>Introduction of various types of disasters and its effect on structures.</i>
2	<i>Learning of quality assurance and damage assessment of structures</i>
3	<i>Educate different types of repair, strengthening, rehabilitation and retrofitting techniques.</i>
4	<i>Awareness about flood characteristics and flood forecasting systems</i>
5	<i>Description of Flood mitigation, adjustment, and regulation</i>

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Understand the fundamentals of disaster and seismic performance of buildings</i>
<b>CO-2</b>	<i>Able to assess various damages in structures and give assurance of quality of concrete</i>
<b>CO-3</b>	<i>Decide the appropriate repair, strengthening, rehabilitation and technique required for a case study of building.</i>
<b>CO-4</b>	<i>Applications of flood routing, flood forecasting and space time characteristics of rainfall.</i>
<b>CO-5</b>	<i>Advanced understanding of flood plain adjustments and employment of appropriate technologies for flood mitigation.</i>

<b>Unit – I</b>
<b>Disaster:</b> Classifications - Causes - Impacts including social, economical, political, environmental, health, psychosocial, etc.
<b>Seismic performance of buildings:</b> case studies of major earthquakes in the country, damage to buildings, damage patterns, performance of non-engineered buildings-Introduction to repair and rehabilitation of structures.

<b>Unit – II</b>
<b>Quality assurance for concrete</b> – Strength, Durability and Thermal properties of concrete. Damage Assessment: - Condition assessment and distress, Purpose of assessment, Rapid assessment - diagnostic techniques, Investigation of damage, , Evaluation of surface and structural cracks, Damage assessment procedure, destructive, non-destructive and semi destructive testing systems, Procedure for evaluating damaged of structure.

<b>Unit – III</b>
<b>Repair, Rehabilitation And Retrofitting Techniques :</b> Repair materials, Common types of repairs – Repair in concrete structures – Repairs in under water structures – Guniting – Shot create –Underpinning, Strengthening of Structural elements, Repair of structures distressed due to corrosion, fire, Leakage, earthquake, Retrofitting techniques



<b>Unit – IV</b>
<b>Introduction to Disasters:</b> Hazard, Vulnerability, Resilience, Risks.-Disaster- Different types of cold wave-heat wave- droughts- floods-Effect of climate change on Processes.
<b>Flood characteristics and forecasting:</b> Measureable features of a flood (Elevation, discharge, volume, and duration), flood forecasting (unit hydrograph method, meteorological and snow data, and snow field air temperatures), operation of flood forecasting systems.
<b>Space-time characteristics of rainfall:</b> Policy criteria for design flood of a major and minor reservoir, spillways, diversion dams and barrages, design flood criteria for dams and other hydraulic structures (CWC recommendations).

<b>Unit – V</b>
<b>Flood Routing:</b> Mathematics of flood routing, various methods of flood routing, Hydrologic and Hydraulic routing.
<b>Flood mitigation:</b> flood ways, channel improvement, evacuation and flood proofing, land management, flood plain management, estimating benefits of flood mitigation.
<b>Flood plain adjustments and regulations:</b> Results of controlling floods, alternatives to controlling floods, range of possible adjustments, practical range of choice, critical characteristics of flood hazards.

**Suggested Reading:**

1	Barry A. Richardson, “Defects and Deterioration in Buildings”, E &FN Spon Press, London, 1991.
2	J. H. Bungey, “Testing of Concrete in Structures”, Chapman and Hall, New York, 1989.
3	“A.R. Santakumar, “Concrete Technology”, Oxford University Press, New Delhi, 2006.
4	“Pankaj Agarwal and Manish Shrikande (2006). “Earthquake Resistance Design of Structures.” Prentice Hall of India.
5	“Ravishankar.K., Krishnamoorthy.T.S, "Structural Health Monitoring, Repair and Rehabilitation of Concrete Structures", Allied Publishers, 2004. New Technological Age”, 2016.
6	CPWD and Indian Buildings Congress, Hand book on Seismic Retrofit of Buildings, Narosa Publishers, 2008.

<b>AC 033</b>	<b>SANSKRIT FOR TECHNICAL KNOWLEDGE</b>				
<b>(AUDIT COURSE - II)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>To get a working knowledge in illustrious Sanskrit, the scientific language in the world</i>
2	<i>To make the novice Learn the Sanskrit to develop the logic in mathematics, science &amp; other subjects</i>
3	<i>To explore the huge knowledge from ancient Indian literature</i>

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Develop passion towards Sanskrit language</i>
<b>CO-2</b>	<i>Decipher the latent engineering principles from Sanskrit literature</i>
<b>CO-3</b>	<i>Correlates the technological concepts with the ancient Sanskrit history.</i>
<b>CO-4</b>	<i>Develop knowledge for the technological progress</i>
<b>CO-5</b>	<i>Explore the avenue for research in engineering with aid of Sanskrit</i>

<b>Unit – I</b>
<i>Introduction to Sanskrit Language: Sanskrit Alphabets-vowels-consonants- significance of Amarakosa-parts of Speech-Morphology-creation of new words-significance of synonyms-sandhi-samasa-sutras-active and passive Voice-Past/Present/Future Tense-Syntax-Simple Sentences (elementary treatment only)</i>

<b>Unit – II</b>
<i>Role of Sanskrit in Basic Sciences: Brahmagupthas lemmas (second degree indeterminate equations), sum of squares of n-terms of AP- sulba, sutram or baudhayana theorem (origination of Pythagoras theorem)-value of pie-Madhava's sine and cosine theory (origination of Taylor's series). The measurement system-time-mass-length-temp, Matter elasticity-optics-speed of light (origination of Michaelson and Morley theory).</i>

<b>Unit – III</b>
<i>Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering):</i> Building construction-soil testing-mortar-town planning-Machine definition-crucible-furnace-air blower- Generation of electricity in a cell-magnetism-Solar system-Sun: The source of energy, the earth-Pingala chandasutram (origination of digital logic system)

**Unit – IV**

*Role of Sanskrit in Engineering-II (Computer Science Engineering & Information Technology):* Computer languages and the Sanskrit languages-computer command words and the vedic command words-analogy of pramana in memamsa with operators in computer language-sanskrit analogy of physical sequence and logical sequence, programming.

**Unit – V**

*Role of Sanskrit in Engineering-III (Bio-technology and Chemical Engineering):* Classification of plants- plants, the living-plants have senses-classification of living creatures, Chemical laboratory location and layout- equipment-distillation vessel-kosthiyanthram

**Suggested Reading:**

1	M Krishnamachariar, “ <i>History of Classical Sanskrit Literature</i> ”, TTD Press, 1937.
2	M.R. Kale, “ <i>A Higher Sanskrit Grammar: For the Use of School and College Students</i> ”, Motilal Banarsidass Publishers, 2015.
3	Kapail Kapoor, “ <i>Language, Linguistics and Literature: The Indian Perspective</i> ”, ISBN- 10: 8171880649, 1994.
4	“ <i>Pride of India</i> ”, Samskrita Bharati Publisher, ISBN: 81-87276 27-4, 2007.
5	Shri Rama Verma, “ <i>Vedas the source of ultimate science</i> ”, Nag publishers, 2005.

<b>AC 034</b>	<b>VALUE EDUCATION</b>					
<b>(AUDIT COURSE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>Understand the need and importance of Values for self-development and for National development.</i>
2	<i>Imbibe good human values and Morals</i>
3	<i>Cultivate individual and National character.</i>

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Gain necessary Knowledge for self-development</i>
<b>CO-2</b>	<i>Learn the importance of Human values and their application in day to day professional life.</i>
<b>CO-3</b>	<i>Appreciate the need and importance of interpersonal skills for successful career and social life</i>
<b>CO-4</b>	<i>Emphasize the role of personal and social responsibility of an individual for all-round growth.</i>
<b>CO-5</b>	<i>Develop a perspective based on spiritual outlook and respect women, other religious practices, equality, non-violence and universal brotherhood.</i>

<b>Unit – I</b>
<i>Human Values, Ethics and Morals:</i> Concept of Values, Indian concept of humanism, human values; Values for self-development, Social values, individual attitudes; Work ethics, moral and non- moral behaviour, standards and principles based on religion, culture and tradition.

<b>Unit – II</b>
<i>Value Cultivation, and Self-management:</i> Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

<b>Unit – III</b>
<i>Spiritual outlook and social values:</i> Personality and Behavior, Scientific attitude and Spiritual (soul) outlook; Cultivation of Social Values Such as Positive Thinking, Punctuality, Love & Kindness, avoiding fault finding in others, Reduction of anger, forgiveness, Dignity of labour, True friendship, Universal brotherhood and religious tolerance.

<b>Unit – IV</b>
<i>Values in Holy Books:</i> Self-management and Good health; internal & external cleanliness, Holy books versus Blind faith, Character and Competence, Equality, Nonviolence, Humility, Role of Women.

**Unit – V**

*Dharma, Karma and Guna*: Concept of soul; Science of Reincarnation, Character and Conduct, Concept of Dharma; Cause and Effect based Karma Theory; The qualities of Devine and Devilish; Satwic, Rajasic and Tamasic gunas.

**Suggested Reading:**

1	Chakroborty, S.K., “ <i>Values &amp; Ethics for organizations Theory and practice</i> ”, Oxford University Press, New Delhi, 1998.
2	Jaya Dayal Goyandaka, “ <i>Srimad Bhagavad Gita with Sanskrit Text</i> ”, Word Meaning and Prose Meaning, Gita Press, Gorakhpur, 2017.

<b>AC 035</b>	<b>STRESS MANAGEMENT BY YOGA</b>					
<b>(AUDIT COURSE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>Creating awareness about different types of stress and the role of yoga in the management of stress.</i>
2	<i>Promotion of positive health and overall wellbeing (Physical, mental, emotional, social and spiritual).</i>
3	<i>Prevention of stress related health problems by yoga practice.</i>

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>To understand yoga and its benefits.</i>
<b>CO-2</b>	<i>Enhance Physical strength and flexibility.</i>
<b>CO-3</b>	<i>Learn to relax and focus.</i>
<b>CO-4</b>	<i>Relieve physical and mental tension through Asanas</i>
<b>CO-5</b>	<i>Improve work performance and efficiency.</i>

<b>Unit – I</b>
Meaning and definition of Yoga - Historical perspective of Yoga - Principles of Astanga Yoga by Patanjali.

<b>Unit – II</b>
Meaning and definition of Stress - Types of stress - Eustress and Distress. Anticipatory Anxiety and Intense Anxiety and depression. Meaning of Management- Stress Management.

<b>Unit – III</b>
Concept of Stress according to Yoga - Stress assessment methods - Role of Asana, Pranayama and Meditation in the management of stress.

<b>Unit – IV</b>
Asanas- (5 Asanas in each posture) - Warm up - Standing Asanas - Sitting Asanas - Prone Asanas - Supine asanas - Surya Namaskar.

<b>Unit – V</b>
<b>Pranayama-</b> Anulom and Vilom Pranayama - Nadishudhi Pranayama – Kapalabhati- Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.

<b>Meditation techniques:</b> Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique ( QRT), Deep Relaxation Technique (DRT).
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**Suggested Reading:**

1	“Yogic Asanas for Group Training - Part-I”: Janardhan Swami Yogabhyasi Mandal, Nagpur
2	“Rajayoga or Conquering the Internal Nature” by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata
3	Nagendra H.R and Nagaratna R, “Yoga Perspective in Stress Management”, Bangalore, Swami Vivekananda Yoga Prakashan

**Web resource:**

1	<a href="https://onlinecourses.nptel.ac.in/noc16_ge04/preview">https://onlinecourses.nptel.ac.in/noc16_ge04/preview</a>
2	<a href="https://freevidelectures.com/course/3539/indian-philosophy/11">https://freevidelectures.com/course/3539/indian-philosophy/11</a>

<b>AC 036</b>	<b>PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS</b>				
<b>(AUDIT COURSE - II)</b>					
<b>Pre-requisites</b>		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>	40 Marks	

**Course Objectives :**

The course is taught with the objectives of enabling the student to:

1	To learn to achieve the highest goal happily
2	To become a person with stable mind, pleasing personality and determination
3	To awaken wisdom in students

**Course Outcomes :**

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

<b>CO-1</b>	Develop their personality and achieve their highest goal of life.
<b>CO-2</b>	Lead the nation and mankind to peace and prosperity.
<b>CO-3</b>	To practice emotional self regulation.
<b>CO-4</b>	Develop a positive approach to work and duties.
<b>CO-5</b>	Develop a versatile personality.

**Unit – I**

Neetisatakam – Holistic development of personality - Verses 19, 20, 21, 22 (Wisdom) - Verses 29, 31, 32 (Pride and Heroism) - Verses 26,28,63,65 (Virtue)

**Unit – II**

Neetisatakam – Holistic development of personality (cont'd) - Verses 52, 53, 59 (don't's) - Verses 71,73,75 & 78 (do's) - Approach to day to day works and duties.

**Unit – III**

Introduction to Bhagavad Geetha for Personality Development - Shrimad Bhagawad Geeta: Unit 2 – Verses 41, 47, 48 - Unit 3 – Verses 13,21,27,35 - Unit 6 – Verses 5,13,17,23,35 - Unit 18 – Verses 45, 46, 48 Unit – 6: Verses 5, 13, 17, 23, 35; Unit – 18: Verses 45, 46, 48.

**Unit – IV**

Statements of basic knowledge - Shrimad Bhagawad Geeta: Unit 2- Verses 56, 62,68 - Unit 12 – Verses 13, 14, 15, 16, 17, 18 - Personality of Role model from Shrimad Bhagawad Geeta.

**Unit – V**

Role of Bahgavadgeeta in the present scenario - Unit 2 – Verses 17 – Unit 3 – Verses 36, 37,

42 - Unit 4 – Verses 18, 38, 39 - Unit 18 – Verses 37, 38, 63.



*With effect from the Academic year 2023-2024*

**Suggested Reading:**

1	“Srimad Bhagavad Gita” by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata.
2	Bhartrihari’s Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit, Sansthanam, New Delhi.

**Web resource:**

1	NTPEL: <a href="http://nptel.ac.in/downloads/109104115">http://nptel.ac.in/downloads/109104115</a>
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<b>AC 037</b>	<b>CONSTITUTION OF INDIA</b>					
<b>(AUDIT COURSE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>The history of Indian Constitution and its role in the Indian democracy.</i>
2	<i>Address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.</i>
3	<i>Have knowledge of the various Organs of Governance and Local Administration.</i>

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Understand the making of the Indian Constitution and its features.</i>
<b>CO-2</b>	<i>Understand the Rights of equality, the Right of freedom and the Right to constitutional remedies.</i>
<b>CO-3</b>	<i>Have an insight into various Organs of Governance - composition and functions</i>
<b>CO-4</b>	<i>Understand powers and functions of Municipalities, Panchayats and Co-operative Societies.</i>
<b>CO-5</b>	<i>Understand Electoral Process, special provisions.</i>

<b>Unit – I</b>
<b>History of making of the Indian constitutions:</b> History, Drafting Committee (Composition & Working). <b>Philosophy of the Indian Constitution:</b> Preamble, Salient Features.

<b>Unit – II</b>
<b>Contours of Constitutional Rights and Duties</b> Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties

<b>Unit – III</b>
<b>Organs of Governance</b> ”: Parliament: Composition, Qualifications, Powers and Functions, Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

<b>Unit – IV</b>
<b>Local Administration</b> - District's Administration head: Role and importance. Municipalities: Introduction, ayor and role of Elected Representative, CEO of Municipal Corporation. Panchayati Raj: Introduction, PRI: Zilla Panchayat, Elected Officials and their roles, CEO Zilla Panchayat: positions and role. Block level: Organizational Hierarchy (Different departments) Village level: role of elected and appointed officials. Importance of grass root democracy.

<b>Unit – V</b>
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<b>Election commission:</b> Election Commission: Role and functioning, Chief Election Commissioner and Election Commissioners, State Election Commission :Role and functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.
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**Suggested Reading:**

1	The Constitution of India”, 1950 (Bare Act), Government Publication
2	Dr. S. N. Busi, Dr. B. R. Ambedkar, “Framing of Indian Constitution”, 1st Edition, 2015.
3	M. P. Jain, “Indian Constitution Law”, 7th Edn., Lexis Nexis, 2014
4	D.D. Basu, “Introduction to the Constitution of India”, Lexis Nexis, 2015.

**Web resource:**

1	<a href="http://www.nptel.ac.in/courses/103107084/Script.pdf">http://www.nptel.ac.in/courses/103107084/Script.pdf</a>
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<b>AC 038</b>	<b>PEDAGOGY STUDIES</b>					
<b>(AUDIT COURSE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives:</b>	
The course is taught with the objectives of enabling the student to:	
1	<i>To present the basic concepts of design and policies of pedagogy studies.</i>
2	<i>To provide understanding of the abilities and dispositions with regard to teaching techniques, curriculum design and assessment practices and familiarize various theories of learning and their connection to teaching practice.</i>
3	<i>To create awareness about the practices followed by DFID, other agencies and other researchers and provide understanding of critical evidence gaps that guides the professional development</i>

<b>Course Outcomes:</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	<i>Illustrate the pedagogical practices followed by teachers in developing countries both in formal and informal classrooms.</i>
<b>CO-2</b>	<i>Examine the effectiveness of pedagogical practices.</i>
<b>CO-3</b>	<i>Understand the concept, characteristics and types of educational research and perspectives of research.</i>
<b>CO-4</b>	<i>Describe the role of classroom practices, curriculum and barriers to learning.</i>
<b>CO-5</b>	<i>Understand Research gaps and learn the future directions.</i>

<b>Unit – I</b>
<i>Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions, Overview of methodology and Searching.</i>

<b>Unit – II</b>
<i>Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.</i>

<b>Unit – III</b>
<i>Evidence on the Effectiveness of Pedagogical Practices: Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and Practicum) and the school curriculum and guidance material best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches – Teachers attitudes and beliefs and pedagogic strategies.</i>

**Unit – IV**

*Professional Development:* alignment with classroom practices and follow up support - Support from the head teacher and the community – Curriculum and assessment - Barriers to learning: Limited resources and large class sizes.

**Unit – V**

*Research Gaps and Future Directions:* Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment – Dissemination and research impact.

**Suggested Reading:**

1	Ackers J, Hardman F, “ <i>Classroom Interaction in Kenyan Primary Schools, Compare</i> ”, 31 (2): 245 – 261, 2001.
2	Agarwal M, “ <i>Curricular Reform in Schools: The importance of evaluation</i> ”, <i>Journal of Curriculum Studies</i> , 36 (3): 361 – 379, 2004.
3	Akyeampong K, “ <i>Teacher Training in Ghana – does it count? Multisite teacher education research project (MUSTER)</i> ”, Country Report 1. London: DFID, 2003.
4	Akyeampong K, Lussier K, Pryor J, Westbrook J, “ <i>Improving teaching and learning of Basic Maths and Reading in Africa: Does teacher Preparation count?</i> ” <i>International Journal Educational Development</i> , 33 (3): 272- 282, 2013.
5	Alexander R J, “ <i>Culture and Pedagogy: International Comparisons in Primary Education</i> ”, Oxford and Boston: Blackwell, 2001.
6	Chavan M, Read India: “ <i>A mass scale, rapid, learning to read campaign</i> ”, 2003

<b>AC 039</b>	<b>E-WASTE MANAGEMENT</b>					
<b>(AUDIT COURSE - II)</b>						
<b>Pre-requisites</b>			<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			2	-		0
<b>Evaluation</b>	<b>SEE</b>	60 Marks	<b>CIE</b>		40 Marks	

<b>Course Objectives :</b>	
The course is taught with the objectives of enabling the student to:	
1	Introduction to E-Waste management
2	Understanding on resource efficiency and circular economy
3	E-waste Management rules 2016
4	RoHS compliances/directives to EEE

<b>Course Outcomes :</b>	
On completion of this course, the student will be able to :	
<b>CO-1</b>	Complete understanding on E-Waste management
<b>CO-2</b>	Understanding on effective recycling methodologies for e-waste management
<b>CO-3</b>	Overall understanding about E-waste Management rules 2016 and strategies for e-waste management
<b>CO-4</b>	Understanding on RoHS compliances for EEE products

<b>Unit – I</b>
Waste Electrical and Electronic Equipment (WEEE): Flows, Quantities and Management, a Global Scenario; The Importance of Waste Management; Types of Waste- Solid and Liquid; Criteria for EEE/E-Waste Classification; Multivariate Model for E-Waste Estimation; Environmental and Health Effects of Waste Management, Inventorisation of E-Waste and Emerging trends in E-waste disposal with bench marks for depollution - global scenario; Dumping, Burning and Landfill: Impact on the Environment

<b>Unit – II</b>
Effective Waste Management and Disposal Strategies; Legislative Influence on Electronics Recycling; Waste Management Rules and Their Amendments; Extended Producer Responsibility (EPR) in E-Waste Management; The Role of Collective versus Individual Producer Responsibility in E-Waste Management

<b>Unit – III</b>
Electronic Waste: Public Health Implications; Restriction of Hazardous Substances (RoHS) Directives in Electrical and Electronic Equipment; Materials Used in Manufacturing Electrical and Electronic Products

<b>Unit – IV</b>
Recycling and Resource Management: Ecological and Economical Valuation; Life Cycle Assessment (LCA) Approach to Waste Management System; Environmental Incentives for Recycling and Life Cycle Analysis of Materials Recycling Electronic Waste: Challenges and Opportunities for Sustainable Management; Resource Recovery from E-waste: Efficiency and Circular Economy; Integrated Approach to E-Waste Recycling: Recycling and Recovery Technologies, Recycling and Recovery Technologies.

<b>Unit – V</b>
Cases studies: E-waste Generation, collection and recycling

**Suggested Reading:**

1	Electronic Waste Management and Treatment Technology, Editors: Majeti Narasimha Vara Prasad Meththika Vithanage
2	Electronic Waste Management, Edited by R. E. Hester, R. M. Harrison, RSC Publishing 2009
3	Solid Waste Technology & Management, Christensen, T., Ed., Wiley and Sons., 2011
4	Electronics Waste Management: An India Perspective. Front Cover. Sandip Chatterjee. Lap Lambert Academic Publishing GmbH KG, 2010 - Electronic
5	Handbook of Electronic Waste Management, International Best Practices and Case studies, Elsevier, 2019
6	E-waste: Implications, regulations, and management in India and current global best practices. Author(s): RakeshJohri, TERI Press

<b>ME 181</b>	<b>DISSERTATION PHASE-I</b>					
<b>Pre-requisites</b>	-		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			-	-	20	10
<b>Evaluation</b>	<b>SEE</b>	-	<b>CIE</b>	100 Marks		

**Objectives:**

- Understand the purpose of Project work
- Learn the resources available at the college and outside for pursuing project
- Importance of literature review
- Learn to select appropriate software and procedure
- Learn to document results and arrive at required conclusions

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

1. Identify suitable engineering problems reviewing available literature.
2. Study different techniques used to analyze the problem
3. Use related techniques and software's for solving the problem
4. Interpret the results(if any) and defend your work in front of technically qualified audience
5. Document the findings as a technical report with proper references

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>				2	3	1
<b>CO-2</b>				2	3	1
<b>CO-3</b>				2	3	1
<b>CO-4</b>				2	3	1
<b>CO-5</b>				2	3	1

**Guidelines**

1. The Dissertation Work should preferably be a problem with research potential and should involve scientific research, design, generation/collection and analysis of data, determining solution and must preferably bring out the individual contribution.



2. Seminar should be based on the area in which the candidate has undertaken the dissertation work as per the common instructions for all branches of M.E..
3. The examination shall consist of the preparation of report consisting of a detailed problem statement and a literature review.
4. The preliminary results (if available) of the problem may also be discussed in the report.
5. The work has to be presented in front of the examiners panel set by Head and Faculty Advisor.
6. The candidate has to be in regular contact with his guide and the topic of dissertation must be mutually decided by the guide and student.

**SEMESTER - IV**

<b>ME 182</b>	<b>DISSERTATION PHASE-II</b>					
<b>Pre-requisites</b>	-		<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
			-	-	32	16
<b>Evaluation</b>	<b>SEE</b>	100 Marks	<b>CIE</b>	100 Marks		

**Course Objectives:**

- *Understand the purpose of doing project work*
- *Learn the resources available at the college and outside for pursuing project*
- *Importance of literature review*
- *Learn to select appropriate software and procedure*
- *Learn to document results and arrive at required conclusions*

**Course Outcomes:** At the end of the course, the student will be able to:

1. Use different Simulation models /experimental techniques/ software/ computational /analytical tools.
2. Design and develop Simulation model/Mathematical model/ experimental set up/ equipment/ test rig.
3. Conduct tests and draw logical conclusions from the results after analyzing them.
4. Work in either in research environment or in an industrial environment and Conversant with technical report writing.
5. Present and defend their work to the evaluation committee.

Course outcome	Program Outcome					
	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
<b>CO-1</b>				2	3	1
<b>CO-2</b>				2	3	1
<b>CO-3</b>				2	3	1
<b>CO-4</b>				2	3	1
<b>CO-5</b>				2	3	1

**Guidelines**

1. It is a continuation of Major Project Phase I work started in semester III.
2. The dissertation should be presented in standard format as provided by the department.
3. The candidate has to prepare a detailed project report consisting of introduction of the problem, problem statement, literature review, objectives of the work, methodology (experimental set up or numerical details as the case may be) adopted & Result analysis.
4. The report must bring out the conclusions of the work and future scope for the study and also should be properly referenced.

*With effect from the Academic year 2023-2024*

5. Student has to submit the report in prescribed format and also present a seminar.
6. Student should present a Seminar in front of Internal committee consisting of Head, CBoS, Guide, Subject expert, Faculty Advisor. Further the suggestions of the committee have to be incorporated in the final Report.
7. The final work has to be presented in front of the examiners panel consisting of an approved external examiner, an internal examiner and a guide, co-guide etc. as decided by the Head.
8. The candidate has to be in regular contact with his/her guide.