DEPARTMENTOF MECHANICALENGINEERING

Scheme of Instruction and Syllabus of

M.E. (Mechanical Engineering)
TOOL DESIGN

With effect from Academic Year 2023-2024

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

With effect from academic year 2023-2024

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

S. No.	Course Name	Contact hours per week		Scheme of Examination		Credits
		L	P	CIE	SEE	
	SEMESTER-I					
1.	Core-I	3	-	40	60	3
2.	Core-II	3	-	40	60	3
3.	Core-III	3	-	40	60	3
4.	Programme Elective-I	3	-	40	60	3
5.	Programme Elective-II	3	-	40	60	3
6.	Programme Elective-III	3	-	40	60	3
7.	Laboratory-I	0	2	50	-	1
8.	Seminar	0	2	50	-	1
	TOTAL	**18**	**4**	**340**	**360**	**20**
	SEMESTER-II					
1.	Core-IV	3	-	40	60	3
2.	Core-V	3	-	40	60	3
3.	Core-VI	3	-	40	60	3
4.	Programme Elective-IV	3	-	40	60	3
5.	Programme Elective-V	3	-	40	60	3
6.	Open Elective	3	-	40	60	3
7.	Mini Project	-	4	50	-	2
8.	Laboratory-II	-	2	50	-	1
9.	Laboratory-III	-	2	50	-	1
	TOTAL	**18**	**8**	**390**	**360**	**22**
	SEMESTER-III					
1.	Audit Course-I (Online)	2	-	40	60	0
2.	Audit Course-II (Online)	2	-	40	60	0
3.	Dissertation-I	-	20	100		10
	TOTAL	**4**	**20**	**180**	**120**	**10**
	SEMESTER-IV					
1.	Dissertation Phase-II	-	**32**	**100**	**100**	**16**
	GRAND TOTAL	**40**	**64**	**1010**	**940**	**68**

Note:

i. Dissertation-II has two parts, CIE - I and CIE – II, at the end of 8th week and 16th 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.

M.E (Mechanical Engineering) Specialization: Tool Design

Type of course	Course Code	Course Name	Contact hours per week			Scheme of Examination		Credits
			L	T	P	CIE	SEE	
SEMESTER-I								
Core-I	ME401	Design of Press Tools	3	-	-	40	60	3
Core-II	ME402	Design of Jigs- Fixtures and Cutting Tools	3	-	-	40	60	3
Core-III	ME403	Metal Cutting and Forming	3	-	-	40	60	3
Programme Elective-I	ME120	Advanced Metrology	3	-	-	40	60	3
	ME113	Manufacturing Automation						
	ME311	Finite Element Techniques						
	ME115	Industry 4.0						
Programme Elective-II	ME126	Experimental Techniques and Data Analysis	3	-	-	40	60	3
	ME127	Non-Destructive Evaluation Techniques						
	ME411	Plant Layout and Material Handling						
	ME114	Manufacturing Management						
Programme Elective-III	ME112	Computer Integrated Manufacturing	3	-	-	40	60	3
	ME122	Product Design Re-Engineering						
	ME123	Tribology						
	ME119	Quality and Reliability Engineering						
Lab-I	ME451	Tool Design Lab	-	-	2	50	-	1
Seminar	ME461	Seminar	-	-	2	50	-	1
		TOTAL	**18**	**-**	**4**	**340**	**360**	**20**
SEMESTER-II								
Core-IV	ME404	Design of Dies	3	-	-	40	60	3
Core-V	ME405	Material Science and Technology	3	-	-	40	60	3
Core-VI	ME406	Hydraulic and Pneumatic Systems	3	-	-	40	60	3
Programme	ME412	Machine Tool Design	3	-	-	40	60	3

Elective-IV	ME105	Computer Aided Manufacturing						
	ME125	Sustainable Manufacturing						
	ME413	Cloud Based Manufacturing						
	ME106	AM Technologies and Applications						
Programme Elective-V	ME414	Advanced Manufacturing Techniques	3	-	-	40	60	3
	ME104	Product Design and Process Planning						
	ME415	Work System Design						
	ME416	Total Quality Management						
	ME132	Manufacturing of Non-Metallic Products						
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-II	ME452	Computational Lab for Tool Design	-	-	2	50	-	1
Lab-III	ME453	Design Simulation lab	-	-	2	50	-	1
		TOTAL	**18**	**-**	**8**	**390**	**360**	**22**
SEMESTER-III								
Audit Course-I	AC 030 ME	Research Methodology in Mechanical Engineering	2	-	-	40	60	0
Audit Course-II	AC 031	English for Research Paper Writing						
	AC 032	Disaster Mitigation & Management						
	AC 033	Sanskrit for Technical Knowledge						

	AC 034	Value Education	2	-	-	40	60	0
	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						
	ME481	Dissertation Phase-I	-	-	20	100	-	10
		TOTAL	**4**	**-**	**20**	**180**	**120**	**10**
SEMESTER-IV								
	ME482	Dissertation Phase-II	-	-	32	100	100	16
		GRAND TOTAL	**40**	**-**	**64**	**1010**	**940**	**68**

CIE: *Continuous Internal Evaluation* ***SEE:*** *Semester End Examination*

Program Outcomes (PO) – Tool Design

1. Apply the knowledge of science, mathematics, and engineering principles for developing problem solving attitude.
2. Ability to identify, formulate and solve engineering problems in the domain of tool design.
3. Use different software tools for analysis and design of press tools, dies and fixtures.
4. Ability to design and conduct experiments, analyze and interpret data, for development of simulation experiments.
5. Function as a member of a multidisciplinary team with sense of ethics, integrity and social responsibility.

ME401	**DESIGN OF PRESS TOOLS**					
(CORE - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:

- To learn the types presses, press tool operations and force calculations and strip layout.
- To understand the various classification of dies, terminology of press tool elements and alignment system design of press tools.
- Learn the design of various dies and principles of design considerations.
- Understand and design of forming dies.

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

CO's	**Description**	**Blooms Level**
CO1	Select/suggestasuitablepresstobeused.Designandeconomicalstriplayoutastothe need of component. Consider application of clearances for dimensioning shearing elements.	L2
CO2	Designvariouselementsofpresstoolaccordingtothetypeofdieforthepressselected. Consider the application of shear if necessary	L4
CO3	Designanappropriatetypedieasperthequalityandquantityoftheproductconfiguration and differentiate the necessity of fine blanking Vs Conventional blanking and design accordingly.	L4
CO4	Decide the type of bending die and design accordingly. Provide necessary correction for spring back. Differentiate between bending and stretch forming.	L3
CO5	Design draw die to suit mechanical or hydraulic press. Understand and consider the various metal forming techniques. Understand drawing and redrawing and can develop a blank and number of stages.	L4

Program Articulation Matrix

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

UNIT– I

Classification of presses– Specification of Presses– Safety Devices in Presses– Principles of loading and unloading equipment– Various press tool operations– Selection of types of presses – Theory of shearing– Clearance concept–Location of clearance for regular and irregular shapes– Analysis of forces– Force, power &energy–Stock strip terms–Layouts–Economic utilization–Dimensioning of punches and die openings with tolerance.

UNIT– II

Classification of dies viz. shearing, bending, drawing & forming– Terminology of press tool elements–Designconsiderationsofvariouselementsviz.dieplates,stockguides,strippers&types– Shedders– Stops- function and types– Pilots- function and types– Punches types– Punches mounted in punch holder– Calculation of spring, rubber, ejector–Shear and its application– Types of shear (cutting with inclined edges)– Alignment system design of press tools.

UNIT– III

Design of dies– Simple piercing/blanking–Inverted die– Compound die– Progressive dies–Rules for developing stock– Strip layouts for progressive dies– Types of progressive dies viz. blank through, slug cutoff and shear cutoff–Load centre– Necessity– Analytical and graphical method to determine load centre (i.e. centre of pressure)– Miscellaneous dies– Shaving, Horn, Cam actuated and precision lamination dies– Fine blanking dies– Principles-design considerations.

UNIT– IV

Bending dies– Theory of bending–Blank development– Spring back effect– Spring back factor– Methods of correction to overcome spring back – both practical and theoretical– Types of bending dies viz. V, U and L– Pressure pad dies– Forces in bending– Construction and working principles– Pressbrake Tooling– Curling–Flanging– Principles of stretch forming– Stretch forming dies.

UNIT– V

Drawing and forming: Definition of drawing, redrawing, reverse redraw–Theory of drawing for metal flow in cylindrical shells– Blank development– Algebraic-centre of gravity, segment area and layout method– Severity of draw– Reduction– Strain factor– Draw force calculation– Draw die edge radius consideration– Blank holder– Stages in draw dies– Calculations– Drawing of rectangular components– Blank development– Drawbeeds–Ironing–Defects in draw – Modern metal forming techniques viz. rubber pad forming, explosive forming, magnetic pulse forming, roll forming– Awareness of various software for sheet metal operations, both for analysis and design.

Suggested Readings:

1. Fundamentals of Tool Design–ASTME, Prentice Hall ,New Delhi,1987
2. Die Design Hand book– AISME, Mc Graw Hills,Newyork,1965
3. Eary & Reed, Shear Working of Metals, Prentice Hall, NewDelhi,1969
4. Basic Die Making & Advance Die Making–D. Eugene Ostergaard, McGraw Hill
5. Tool Design by Cyril Donaldson– Tata Mc Graw Hill, New Delhi.

ME402	**DESIGN OF JIGS–FIXTURES AND CUTTING TOOLS**					
(CORE - I)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:

- To learn the fundamentals of single point and multi point cutting tools.
- To understand the working principle of jigs & fixtures and their applications.
- To design the various types and elements of jigs & fixtures.
- To understand types, principle and applications various gauges.

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

CO's	**Description**	**Blooms Level**
CO1	Select/design a suitable standard cutting tool or special tool as to the need of the job &machining process- Drilling, Turning& Deep hole drilling.	L2
CO2	Select/Design an appropriate cutting tool to perform Milling, Threading, Gear cutting & Broaching operations.	L2
CO3	Concave proper location, clamping technique, utilizing standard elements while designing a suitable jig or a fixture to achieve job tolerance.	L3
CO4	Design an efficient & economic jig or a fixture for various Machining operations ass to the product requirement. Understand and able to conceive the	L4
CO5	Decide & Design a suitable Gauge for checking a Job with given tolerance and feature.	L4

Program Articulation Matrix

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

UNIT-I

Cutting Tools: Development of cutting tool materials. Design of single point tools for turning Nomenclatures of single point Cutting tools, Inserts & Holders. Calculations of tool profile for Flat

Form tools & Circular Form tools. Design-Nomenclatures of Drills, Reamers, Boring tools. Deep hole drilling methods& Tools. Exercise on Form tools & Drilling Cutter for the given job.

UNIT-II

Milling Cutters–types, design calculation & details. Methods for thread cutting & forming–Design of threading Taps & circular threading Dies. Gear cutting & generation methods–involute geometry for gears, conjugate profile–Design of hobs. Broaching process & types. Design of broaches. Design of tools for CNC machines. Exercise on Broaches,

UNIT-III

Jigs &Fixtures: Tolerance analysis and procedure of designing. The economic calculations, Principles of location of the work piece, degree of freedom, references surfaces, resting components & redundancy. 3-2-1 & 4-2-1, Flat, Concentric, Vee, Radial & Self-centring locations. Application of Diamond pin .Fixed & Adjustable Resting elements. Clamping principles and methods of clamping. Application of standard elements viz Strap, C, Floating pad Spherical washer etc. Equalizers & Quick clamping methods. Jig Bushes-design & types. Cutter setting blocks.

UNIT-IV

Design principles of Jigs & Fixtures. Design of Drill Jigs & types viz. Plate, Post, Box, Leaf, Invertible, indexing etc. Design of milling fixtures. Application & design of standard & special accessories for turning operations. Lathe fixtures on the face plate. Design of broaching fixtures. Introduction to Inspection, Welding, Assembly & CNC fixtures. Exercises on design of Drill Jigs, Milling & Turning fixtures. Use of various softwares for design & analysis.

UNIT-V

Gauges: Plain limit gauges: Review of systems of tolerances, fits and tolerance analysis (IS:919, 170) Taylors principles and its applications. Calculation of dimensions and design details of plain gauges: Study of standard tapers and methods of dimensioning. Thread Gauges. Types and design calculations of spline gauges–Functional Gauges–CNC Gauging. Exercise on Design of plain Gauges, Taper Gauges, and Thread Ring Gauges.

Suggested Readings:

1. Henrickson, *Manual of Jigs and Fixtures Design*, Industrial Press Inc.,New York, 1973.
2. Joshi, *Jigs and Fixtures*, Tata McGraw Hill, New Delhi,1996.
3. *Fundamentals of the Tool Design*, ASTME, Prentice-Hall of India Private Ltd., New Delhi, 1976.
4. Shaw Mc, *Metal Cutting Principles*, Oxford, IBH Publ., Calcutta 1957.
5. Juneja BL, *Theory and Application of Metal Cutting*, Wiley Eastern Ltd., New Delhi,1987.

ME403	METAL CUTTING & FORMING					
(CORE - I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:

- To understand the types and properties of cutting tools and their applications to various metals.
- To know the cutting forces, temperature, tool wear and tool life.
- To learn the principles and types of conventional and unconventional deformation methods.

COs	Description	Blooms Level
CO1	Develop interrelations among ASA, ORS and NRS systems of tool geometry.	L2
CO2	Analyze cutting forces, temperature, power and specific energy along the shear and rake Planes	L4
CO3	Understand the Tool Wear, Tool life and Machinability concepts	L3
CO4	Understand the mechanism of plastic deformation of metals	L3
CO5	Know the principle and applications of un-conventional forming techniques	L4

Program Articulation Matrix

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

UNIT-I

Tool Materials: Desirable Properties of tool materials, Types of Cutting Tool Materials, Indexable inserts, Coated tools, Orthogonal and Oblique cutting, Classifications of cutting tools, Chip formation, Types of chips, Cutting tool geometry, various methods of tool nomenclature and their relationships. Theoretical Determination of shear angle and cutting forces: Shear plane theory–Merchant's models, Lee and Shaffer's model. Velocity relationships, Workdone in cutting.

UNIT-II

Dynamometry: Dynamometer requirements –Strain gauges for Force measurements – Electric

transducers. Types of dynamometers-Lathe, milling and grinding dynamometers. **Cutting Temperatures**: Shear Plane temperature, Average chip-tool interface temperature-Distribution of shear plane temperature, Measurement of temperature by radiation pyrometer, tool-work thermo couple, Photo cell, and Photographic method.

UNIT-III

Tool Wear, Tool life and Machinability: Mechanism of tool wear–Adhesive, Abrasive, Diffusive and Chemical wear–Taylor's tool life equation. Cutting Fluids–Direction of fluid application–Chip curl-economics of machining –Comparison of machinability of different metals. Recent development in metal cutting: Hot machining. Rotary machining– High speed machining.

UNIT-IV

Plastic Deformation: Factors affecting plastic deformation, Strain hardening behavior. Variables affecting Stress-strain curves, Ideal & Practical stress-strain curves. Cold working, warm working and hot working. Plasticity cycle. Tresca's and Von Mises's yield criteria under complex states of stress, including Plane stress & Plane strain condition. Rolling: Principle of rolling, process parameters. Estimation of rolling loads. Principles of roll pass design for various product shapes. Principles of ring rolling.

UNIT-V

Unconventional Methods In Metal Forming: High energy rate forming. Merits and limitations of HERF Processes. Principle, merits, limitations and applications. Explosive forming, electro-magnetic forming, electro-hydraulic forming and water hammer forming, Rubber pad forming.

Suggested Reading:

1. M.C. Shaw. *Metal cutting principles*– CBS Publications, New Delhi,1992.
2. Bhatta Charya, *Metal cutting* – Central book publishers, Calcutta– 1996.
3. Heinrich Makelt, *Mechanical presses*, Edward Arnold (Pvt) Ltd., London,1968.
4. Bary. Donald. F and Reads. Edward A., *Techniques of press working sheet metal*, Prentice Hall Publ., 1974.
5. Kameschikov, *Forming Practice*, Mir Publishers, Moscow, 1970
6. *High Velocity Forming methods*, ASTME, Michigan, 196

ME120	ADVANCED METROLOGY					
(Program Elective-I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:

1. To Learn the Industrial practice of length measurement
2. To Study the Dimensional of parts manufactured the process
3. To Study the geometrical forms of parts

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

1. Understand the functioning of slip gauges, micro meter and concept of inter changeability
2. Understand the working of Fixed and Indicating gauges
3. Know the working of measuring machines
4. Identify various types of form errors and their rectification
5. Understand the measurement of screw threads and gears

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
CO 5	3	3	3	2	3

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, and 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, Preprocess, 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,* Khanna Publishers

2. ASTME, *Hand Book of Industrial Metrology,* Prentice Hall of India Pvt Ltd. 3. I.C. Gupta, *A Text Book of Engineering Metrology,* Dhanpat Rai& Sons.

ME114	MANUFACTURING AUTOMATION					
(Program Elective-I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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

CO's	Description	Blooms Level
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

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

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, and 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. MikellP. Grover, Automation, Production Systems and Computer Integrated Manufacturing, Pearson Education Asia.
2. C.Ray Asfahl, Robots and manufacturing Automation, John Wiley and Sons NewYork.
3. N.Viswanadham and Y.Narahari, Performance Modeling of Automated Manufacturing Syetms, Printice Hall India Pvt.Ltd.
4. Stephen J. Derby, Design of Automatic Machinery, Special Indian Edition, Marcel Decker, New York, Yesdee publishing Pvt. Ltd, Chennai

ME501	FINITE ELEMENT TECHNIQUES					
(Program Elective-I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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

CO's	Description	Bloom s Level
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

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

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, 2Delements. 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 isoparametric elements and numerical integration. Plane stress, plane strain and axisymmetric problems, Body forces and temperature effects. Stress calculations, Plate and shell 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, Prentice Hall of India, 1997.
2. Rao S.S., The Finite Element Methods in Engineering, Pergamon Press, 1989.
3. Segerland. L.J., Applied Finite Element Analysis, Wiley Publication, 1984.
4. Reddy J.N., An Introduction to Finite Element Methods, Mc Graw Hill Company, 1984.
5. P.Seshu, Text book of Finite Element Analysis, PHI Learning Pvt. Ltd., 2003

ME115	INDUSTRY 4.0					
(Program Elective-I)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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

CO's	Description	Blooms Level
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

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	3	1	2	3	
CO3	2	2	3	3	
CO4	3	1	2	3	
CO 5	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" Springer Series, 1st ed. 2018 edition.
2. Alasdair Gilchrist, "Industry 4.0: The Industrial Internet of Things", Apress, 1st edition, 2019.
3. Dr.-Ing. Klaus Schwab, "The fourth Industrial Revolution", Penguin Publisher; 01 edition, 2017.

ME126	EXPERIMENTAL TECHNIQUES AND DATA ANALYSIS					
(Program Elective-II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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:

CO's	Description	Bloom s Level
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

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	1		3	1	3
CO2	1		3	2	3
CO3	2		3	3	3
CO4	1	1	2	2	2
CO 5	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 shredding 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, 8th Edition, McGraw Hill Int., New York, 2012.
2. Venkatesh, V.C., and Chandrasekharan, Experimental Methods in Metal Cutting, 1st 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, 3rdedition,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), 1st Edition, Springer, 1999.
6. Tapan P. Bagchi, Taguchi Methods Explained, 1st Edition, Prentice Hall of India, Delhi, 1993.

ME127	NON-DESTRUCTIVE EVALUATION TECHNIQUES					
(Program Elective-II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

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

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

CO's	Description	Blooms Level
CO1	Comprehend the basic principles of non-destructive testing (NDT) methods	L2
CO2	Identify appropriate nondestructive testing methods for failure identification	L2
CO3	Select NDT methods for quality analysis of industrial components	L3
CO4	Analyse and interpret results from various NDT techniques along with calibration of these NDT.	L4
CO5	Illustrate the advanced NDT techniques used in medical and non-medical field.	L2

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2		1	1
CO2	2	1		1	1
CO3	3	1	1	2	1
CO4	2	3	1	3	1
CO 5	2	2	1	1	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 fibre optics, 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 Reading:

1. Barry Hull, "Non-Destructive Testing"–Vernon John, ELBS/ Macmillan, 1988.
2. Baldev Raj, T.JayaKumar, M.Thavansimuthee, "Practical Non-Destructive Testing" - Narosa Publishing House, New Delhi, 1997.

ME411	PLANT LAYOUT AND MATERIAL HANDLING					
(Program Elective-II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:

- To know the fundamentals of Plant layout and classify different types of layouts
- To study various heuristics in plant layout and understand various types of material handling systems.
- To understand the functioning of conventional and modern material handling equipment and also the cost and maintenance of the equipment.

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

CO's	Description
CO1	Classify various types of Plant layouts and compare them
CO2	Apply various types of heuristics for developing Plant layouts.
CO3	Analyze the features of different types of software's used for modelling plant layout.
CO4	Classify various types of material handling systems and compare the Traditional and Modern Material Handling Equipment**.**
CO5	Identify the methods to minimize the cost of material handling and illustrate the cost of maintenance of material handling equipment.

Program Articulation Matrix

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

UNIT– I:

Introduction

Objectives of Plant layout, Classification of Layout, Advantages and Limitations of different layouts, Layout design procedures. Overview of the plant layout. Process layout& Product layout, Cellular Layout, Selection, specification. Implementation and follow up. Comparison of various layouts.

UNIT– II:

Heuristics for Plant layout

Heuristics for Plant layout-ALDEP. CORELAP, CRAFT, Group Layout, Fixed position layout-Quadratic assignment model. Branch and bound method. Plant layouts software features: Smart® 3D, Plant Design & Management Software (PDMS**),** Plant design software (PDS), Auto PLANT, AD Worx, AutoCAD, FLEXSIM, PROMODEL

UNIT– III:

Introduction to Material Handling systems.

Material handling principles. Classification of Material Handling Equipment, Relationship of material handling to plant layout. Basic Material Handling systems: Selection, Material Handling method-path, Equipment, function oriented systems.

UNIT–IV:

Traditional and Modern Material Handling Equipment

Equipment for handling unit load and bulk materials, namely pulley blocks, winches, electric hoists, EOT cranes, belt conveyor, Bucket elevator, Screw conveyor and pneumatic conveyor. Kinematic analysis and design procedures of their component mechanisms. Design concept of warehouse facilities commensurate with adopted kind of handling and transfer devices. Concepts of Conveyor Belt, AGVs, AS/RS and other automated materials handling devices. Automated packaging devices; design of Integrated Plant Layout for Product Handling Systems.

UNIT– V:

Cost and Maintenance of Material Handling Equipment

Methods to minimize cost of material handling, Maintenance of Material Handling Equipment's, Safety in handling. Ergonomics of Material Handling equipment. Design of Miscellaneous equipment's.

Suggested Readings:

1. RL Francis, LF Me Linnis, Jr, White, "Facility Layout & Location an analytical approach"
2. Ray. Siddharth, "Introduction to Material handling" New Age Publications
3. Mikell. P. Groover**, "**Automation, Production Systems, and Computer-Integrated Manufacturing", Pearson International 3rdEdition.
4. Plant Layout and Material Handling/RB Chowdary/Khanna Publishers.

ME114	MANUFACTURING MANAGEMENT					
(Program Elective-II)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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:

CO's	Description	Blooms Level
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

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	2	1	1	
CO2	2	2	3	1	1
CO3	3	2	1	1	
CO4	2	2	1	1	
CO 5	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 Kalpak jain and Steven R. Schmid, Manufacturing Engineering and Technology, Pearson Education Inc., 4th Edition, 2013.
2. Peter Gibson, R. Kerr, "Manufacturing Management: Principles and Concepts", Springer; 1995
3. S.Sadagopan, ERP: A managerial Perspective, Tata McGraw-Hill publishing company Limited,
4. KanishkaBedi, Production and Operations Management, Oxford University Press, 3rd Edition, 2013.

ME112	COMPUTER INTEGRATED MANUFACTURING					
(Program Elective-III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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:

CO's	Description	Blooms Level
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

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	1
CO2	3	2	3	1	
CO3	3	2	3	1	
CO4	1	2	2	1	
CO 5	1	3	1	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, Principles of Computer Integrated Manufacturing, Printice-HallIndia,1998
2. Nanua Singh, Systems Approach to Computer Integrated Design and Manufacturing, John Wiley, 2011
3. P.Radhakrishnan, S.Subramanyam, V. Raju, CAD/CAM/CIM, New Age International, 2018
4. A. Alavudeen, N.Venkateshwaran: Computer Integrated Manufacturing, Printice-Hall India, 2008
5. Mikell P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 4th Edition, Pearson Publication, 2016

ME122	PRODUCT DESIGN RE-ENGINEERING					
(Program Elective-III)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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.

CO's	Description	Blooms Level
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

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

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, nonferrous 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

Retention, 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**, McGraw Hill Co., 1986, 1999.

2. K.G. Swift, **Knowledge based design for Manufacture**, Kogan page Limited, 1987.

3. O. Molloy, E.A. Warman, S. Tilley, **Design for Manufacturing and Assembly**, Springer Science & Business Media, 1998

4. David M. Anderson, **Design for Manufacturability**, CRC Press, 2014.

5. Geoffrey Boothroyd, Peter Dewhurst, Winston A. Knight, **Product Design for Manufacture and Assembly**, CRC Press Third Edition.

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

CO's	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 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/nano tribology - 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", Elsevier Limited, 1992.
2. G. W. Stachowiak, A. W. Batchelor, "Engineering Tribology", Elsevier Limited, 2005.
3. K.C. Ludema, "Friction, wear, lubrication: A text book in tribology", CRC Press, 1996.
4. Bharat Bhushan, "Principles and applications of tribology", John Wiley & Sons, 1999.
5. Bharat Bhushan, "Nanotribology and Nanomechanics: An Introduction", Springer, 2008.

ME119	**QUALITY AND RELIABILITY ENGINEERING**					
(Program Elective-III)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		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 ISO900 , TQM etc. and their basic principle of working & implementation techniques.
- To study Reliability Engineering for assessment & improvement of systems reliability using various hazard models.

CO's	**Description**	**Blooms Level**
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 ISO900, 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

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

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, 1st Edition.
3. Philipposs, "Taguchi Techniques for Quality Engineering", McGraw Hill, 1996, 2nd Edition.
4. E.Bala Guruswamy, "Reliability Engineering", Tata McGraw Hill, 1994.
5. LS Srinath, "Reliability Engineering", Affiliated East West Pvt. Ltd., 1991, 3rd Edition

ME 451	**TOOL DESIGN LAB**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	25		

Course Objectives:

- To perform design of sheet metal dies, calculation of cutting forces and measurement of cutting temperature. ***Instruction***
- To understand experimental procedure on extrusion, spinning, EDM, UTM, Fatigue and CNC.
- To understand the design principles of jigs, fixtures and press tools.

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

CO's	**Description**	**Blooms Level**
CO1	Study the chip morphology and evaluate chip thickness and shear angle	L2
CO2	Perform formability studies on sheet metals.	L2
CO3	Perform experiments on CNC lathe and Mill.	L4
CO4	Evaluate the mechanical properties of welded joints	L5
CO5	Design a jig or a Fixture for a given component.	L5

Program Articulation Matrix

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

List of Experiments:

1. Study of the morphology of chips produced from different materials sand 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 the water hammer equipment and hydrostatic extrusion setup.
5. Extrusion of cylindrical billets through dies of different included angles and exit diameters and their effect on extrusion pressure.
6. Practice and study of blanking and punching process and their characteristic features on mechanical press with existing dies.
7. Experiments on EDM to measure MRR and Surface roughness of different metals.
8. Programming and experiments on CNC milling for different profiles.
9. Programming and experiments on CNC lathe for cylindrical jobs.
10. Experiments on MIG/MAG or TIG and MIG welding to find out the mechanical properties of metals.
11. Testing of mechanical properties of metals by using UTM.
12. Fatigue Testing of metals on Rotary Fatigue Testing Machine.
13. Wear testing of tools on PIN on DISC and Abrasion Tester.
14. Design a jig for a given component and draw assembly and detailed drawing of the designed jig.
15. Design a Fixture for a given component and draw assembly and detailed drawing of the designed fixture.
16. Design and draw assembly and detailed drawing of a progressive die for a given component

ME 461	**SEMINAR**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	25		

Course Objectives :

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

1 *Understand the purpose of seminar*

2 *Learn the resources available at the college and outside for pursuing project*

3 *Importance of literature review*

4 *Learn to document results and arrive at required conclusions*

Course Outcomes :

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

CO-1 *Identify engineering problems reviewing available literature.*

CO-2 *Study the different techniques adopted to solve the problem.*

CO-3 *Understand the usage of related techniques and software's*

CO-4 *Investigate the procedure adopted and Interpret the results and conclusions obtained*

CO-5 *Document the findings as a technical report with proper references.*

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

The seminar must be clearly structured and Power point presentation should include the following:

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

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.

Guidelines for awarding marks		
S. No.	**Description**	**Max. Marks**
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 few research papers from Peer-reviewed or UGC recognized 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 references
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

ME404	**DESIGN OF DIES**					
(Core-IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:

- To learn the types, materials, moulds& its terminology and applications of plastics.
- To design the moulds, design approach and process variables.
- To design of dies for metal casting and design of forming tools.
- To understand design concepts of finisher impression dies.

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

CO's	**Description**	**Blooms level**
CO1	Understand the plastics, types and their processing methods. Design the various elements with feed and ejection system as per the requirement of the product.	L1
CO2	Design moulds with necessary mechanism to facilitate the moulding of the product with special features.	L4
CO3	Design the pressure casting dies and various elements to suit the process with relevant design considerations for various process variables.	L4
CO4	Understand the importance of forging, types of forging and their methods and apply tolerances as per IS:3469.	L1
CO5	Design finisher impression and other preliminary forging stages in detail and differentiate between reduce role forging and conventional die forging	L4

Program Articulation Matrix

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

CO4	3	3	2	3	1
CO 5	3	3	2	3	1

UNIT– I

Definition of Plastics–Development–Types of Plastics viz. thermo plastic and thermo setting plastics–Types plastic materials for both and their application–Methods of processes-a bird's eye view–Mould terminology–Construction–Mold cavities, cores–Bolsters types–Standard mold base–Ejection system and techniques–Feed system design–sprue, runner and gate–Efficiency of runner– Functions of gate–Types of gate, application– Mold cooling.

UNIT– II

Design of moulds: for external undercuts (Splits)–Side core & cavities–Methods of actuating– Moulds for internal undercuts–Moulds for threaded components–Multi daylight moulds– Under feed moulds–Details–Runner less moulds–Design approach and process variables for transfer moulds and compression moulds.

UNIT– III

Design of dies for metal casting-Various casting processes–Die casting dies–Terminology applicable to process viz. hot chamber, cold chamber (horizontal and vertical) process– Terminology applicable to dies – Alignment of metal flow in hot chamber, horizontal cold chamber and vertical cold chamber machines–Modification for casting deep core or with limitations of stroke– Design for various elements– Effect of off-centre cavity Layout–Necessity of balancing– Types of dies viz. single cavity, multi cavity, combination and unit die–Runner, gate calculations– Various parameters influencing the Runner gate design-Ejection mechanism– Ejection elements and various locations–Die locking mechanism–Types of alloys–Trimming– Types of trim dies.

UNIT– IV

Bulk metal forming tools–Forging dies–Definition–Influence of temperature and external pressure–Glossary words applicable informing dies–Types of forging dies, open die forming closeddieforging–Methodsofopendieforging–Allowanceandtolerancesapplicable to closed die forging– Factors to be considered– Forging equipment–Layout of forge shop

UNIT– V

Design of finisher impression–Preparation of forging drawing–Design of fuller – Types of fuller– Design of blocker and consideration–Design of edge rolling impression–Design of bender– Planning layout of multi impression dies–procedure–Flash and, gutter–Importance– Calculations– Capacity calculations for hammers & presses–Trimming dies-Push through and compound– Upsetting–Rules for simple upsetting–Press forging or reduce roll forging concepts– Forward and backward extrusion.

Suggested Readings:

1. Rusinoff S.E.Forging & forming Metals,Taraporewala,1952
2. Dochlar H.H., Die Casting Dies, McGrawHill,1951
3.I.S. Standards, BSI, New Delhi
4. Pye R.G.W.,Injection Mould Design, Longman Scientific & Technical Publishers, London, 1989

ME405	MATERIAL SCIENCE AND TECHNOLOGY					
(Core-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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 tools steels, and specifications of die castings

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

CO's	Description	Blooms Level
CO1	Recognize strengthening mechanisms of metals and Categorize the behaviour of fracture, creep and fatigue in materials	L2
CO2	Determining mechanical properties and understand the concepts of fracture analysis	L3
CO3	Classify the tool and die steels and interpret the applications, properties and composition of various tool steels, modern cutting tool materials and plastics	L4
CO4	Distinguish the requirements and specifications of ferrous and nonferrous die castings according to Bureau of Indian Standards(IS)	L3
CO5	Assess the heat treatment of various types of tool steels.	L3

Program Articulation Matrix

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3		1	2	2
CO2	3		1	3	2
CO3	3		2		
CO4	3		2		
CO 5	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, 6th 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, 2nd Edition, McGraw Hill Book Company, 1974.
4. William E. Bryson, Heat Treatment, Selection, and Application of Tool Steels, 2nd edition, Hanser Publishers, 2009.
5. George Krauss, "Steels; Processes, Structure& Performance", ASM International, The Materials Information Society, 2005 IS Standards, BIS, New Delhi.

ME406	HYDRAULIC AND PNEUMATIC SYSTEMS					
(Core-V1)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:

- To understand the types fluid power, advantages of fluid power, application of fluid power system.
- To know the basics of hydraulics and properties of hydraulic fluids.
- To design of simple hydraulic, pneumatic circuits and servo systems.

CO's	Description	Blooms Level
CO1	Understand fluid power systems	L2
CO2	Gain knowledge on pumps and compressors	L4
CO3	Exhibit the knowledge on selection of components of fluid power systems	L3
CO4	Design pneumatic and hydraulic circuits	L3
CO5	Operate LCA and FMS	L4

Program Articulation Matrix

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

Unit-I:

Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, Compressibility and incompressibility of fluids–Stagnation states, Mach waves and Mach cone–Effect of Mach number on compressibility–Isentropic flow through variable ducts–Nozzle and Diffusers. Ideal Gas equations-Applications of Pascal's Law– Laminar and Turbulent flow–Reynolds number–Darcy's equation–Losses in fluid power system.

Unit II:

Basics of Hydraulics –Properties of hydraulic fluids –Sources of Hydraulic Power-Pump classifications– Construction and working of Pumps– Pump performance– comparison of pumps. An overview of Basic hydraulic system. Basics of Pneumatics -Properties of compressed air-Sources of Pneumatic Power-Types of compressor-Construction and working of compressor-Performance of compressor-An overview of Basic pneumatic system-Comparison of pump and compressor–Need for compressed air conditioning –pneumatic dryer–Filter, regulator and lubricator –fluid power accumulators–purpose and types. Distribution of Fluid power and safety measures.

Unit-III:

Fluid power actuators-selection of actuators –pneumatic and hydraulic actuators –types and ISO symbols– linear and rotary. Construction and working of double acting cylinder– special actuators–rodless, tandem, impact, duplex and telescopic cylinders.–types of actuating mechanism. sensors–limit switches, reed switches and pressure switches Cushioning mechanism in pneumatic and hydraulic cylinders. Control valves–types of valves. Construction and working of control valves -3/2, 4/2, 5/3 and 4/3 Direction control valve, flow control valve, classification and working of pressure control valves, sequencing and relief valve.

Unit-IV:

Design of simple hydraulic and pneumatic circuits-Speed and force calculation of linear actuator. Design considerations of pneumatic and hydraulic circuits. meter in, meter out and counter balancing circuits. Design of multi cylinder pneumatic and hydraulic sequencing circuit. Fluidics–Introduction to fluidic devices, simple circuits. Design of simple Electro pneumatic and Electro hydraulic circuits. Design of Multi cylinder electro pneumatic and electro hydraulic circuits–Ladder diagram. conflict signals–identification of conflict signal. Cascading method–step counter method, Karnaugh-Veitch method and combinational circuit design.

Unit V:

Servo systems– Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves. Pneumatic PID circuits. PLC applications in fluid power control, ladder diagrams, Timers and counters. Low Cost Automation using pneumatics and Flexible manufacturing system. Fluid power circuits; failure and troubleshooting FIELD WORK Case study on applications using1. PLC2.FMS3. Servo system.

Suggested Readings:

1. Anthony Esposito, Fluid Power with application,PrenticeHall,2013.
2. Majumdar S.R., OilHydraulics, Tata McGraw-Hill, New Delhi2009
3. Anderson,J.D., "Modern Compressible flow", 3rd Edition, McGraw Hill,2003
4. A textbook of Basic Pneumatics, SMC Pneumatics, 2012.
5. A textbook of Electro Pneumatics, SMC Pneumatics, 2012.
6. Harry Stevart D.B, Practical guide to fluid power, Taraoealasons and Port Ltd. Broadey,1976.
7. MichaelJ, Prinches and Ashby J . G, Power Hydraulics, Prentice Hall,1989

ME412	MACHINE TOOLD ESIGN					
(Program Elective-IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives:

- To familiarize students with the machine tool types and kinematics of design
- To understand the various forces acting on machine tool elements
- To study the effects of motion on various elements by vibration and its methods
- To machine specification and testing with validation procedure through industry standards

CO's	Description	Blooms Level
CO1	Understand type of kinematics and its dynamics of operation of machine tools	L2
CO2	Derive the new mechanism application	L4
CO3	Design of machine tool structures for the given application	L3
CO4	Enhance the Machine tool kinematics for innovative application	L3
CO5	Test and validate machine tools structure suitable to application	L4

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

UNIT-I

Classification of Machine Tools: General purpose, Special purpose, Automatic, Semi-Automatic machine tools, Transfer lines. Kinematics of Machine Tools: Shaping of geometrical and real surfaces, Developing and designing of kinematics schemes of machine tools, Kinematic structures of lathe, drilling, milling, relieving lathe, grinding, gear shaping and gear hobbing machining. Kinematic design and speed and feed boxes. Productivity loss. Stepped and stepless regulation.

UNIT-II

Strength and Rigidity of Machine Tool Structures: Basic principles of design for strength.

Different types of structures. General design procedures. Effect of materials and shape factors on the rigidity of structure, overall compliance of machine tool. Design of beds, bases columns, tables, cross rails for various machines. Effect of wear of guide ways on the performance. Various types of guide ways, their relative advantages. Materials for machine tool components including plastic guide ways (PTFE).

UNIT-III

Analysis of Spindles, Bearing and Power Screws: Design of spindles subjected to combined bending and torsion. Layout of bearings. Pre-loading. Anti-friction slide ways. Rolling contact, hydrodynamic, hydrostatic, aerostatics and magnetic bearings, their relative performance. Power Screws, Recirculating ball screws. Hydrodynamic design of journal bearings.

UNIT-IV

Machine Tool Vibrations: Effect of vibration on machine tool; Forced vibrations. Machine tool chatter. Self excited vibration and dynamic stability single and two degree freedom analysis. Comply coefficient. Elimination of vibration. Vibration analysis of machine tool structures.

UNIT-V

Hydraulic Systems: General principles, hydraulic fluid power lines. Properties of hydraulic fluid. Various positive displacement pumps, their characteristics and operation. Design of hydraulic tanks and other systems. Various valves used in hydraulic systems. Design and application of various hydraulic circuits. One position and multi-position scheme. Single and multi pump screws. Electrical analogy. Pneumatic circuits. Hydro copying system. Evaluation of machine tools with regard to accuracies, sound and vibration. Machine tool testing.

Suggested Reading:

1. Sen and Bhattacharya, *Principles of Machine Tools*, New Central Book Agency, Calcutta, 1975.
2. S.K. Basu, *Design of Machine Tools*, Allied Publishers, India, 1961.
3. Acharkan, *Machine Tool Design (vol. 1,2 & 3)*, MIR Publishers, Moscow, 1973.

ME105	COMPUTER AIDED MANUFACTURING					
(Program Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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:

CO's	Description	Blooms Level
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

Course outcome	Program outcome				
	PO1	PO2	PO3	PO4	PO5
CO1	3	1	2	1	1
CO2	3	2	3	1	
CO3	3	2	3	1	
CO4	1	2	2	1	
CO 5	1	3	1	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, Principles of Computer Integrated Manufacturing, Printice-HallIndia,1998
2. Nanua Singh, Systems Approach to Computer Integrated Design and Manufacturing, John Wiley, 2011
3. P.Radhakrishnan, S.Subramanyam, V. Raju, CAD/CAM/CIM, New Age International, 2018
4. A. Alavudeen, N.Venkateshwaran: Computer Integrated Manufacturing, Printice-Hall India, 2008
5. Mikell P. Groover, Automation, Production Systems and Computer-Integrated Manufacturing, 4th Edition, Pearson Publication, 2016

ME125	SUSTAINABLE MANUFACTURING					
(Program Elective-IV)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		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:

CO's	Description	Blooms Level
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

Course outcome	Program outcome				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3	2	1	1	1
CO2	3	2	3	3	1
CO3	3	1	2	1	
CO4	3	2	1	1	1
CO 5	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 system design. Light weighting and material reduction. Designing for a lifetime. Design for durability, design 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 2006. Design for the Life Cycle. Life-cycle Engineering Laboratory, Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University.
2. Finster, Mark P., 2013. Sustainable Perspectives to Design and Innovation.
3. Ramaswamy, Rohit, 1996. Design and Management of Service Processes: Keeping Customers for Life, Prentice Hall.
4. Schmitt, Brent, 2003. Customer Experience Management, Wiley and Sons

ME413	CLOUD BASED MANUFACTURING					
(Program Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:

- To acquaint the application of cloud computing in manufacturing enabling high level integration of product development phases
- To understand different tools and methodologies used for cloud based product management .
- To familiarize the students concepts of Sustainable manufacturing

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

CO's	Description	Blooms Level
CO1	Comprehend the concept of cloud based distributed environment for collaborative manufacturing.	L2
CO2	Develop cloud community for small and medium industries	L3
CO3	Describe the application of cloud computing in manufacturing enabling high level integration of product development phases.	L3
CO4	Apply cloud concepts in a sustainable and global product development	L3
CO5	Describe different tools and methodologies used for cloud based product management	L2

Program Articulation Matrix

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

UNIT-I

Cloud based manufacturing systems: Introduction to cloud computing – definition- architecture of cloud manufacturing-resouce requirements – service oriented manufacturing environment – IaaS, SaaS, PaaS, interoperability of systems, cloud based systems and interoperability – virtual service layer

UNIT-II

Distributed service: definition – application of manufacturing ,assembly processes and management of products for recycling of e-waste – customizable decision making model. Development of cloud community for small and medium industries

UNIT-III

Integrating OEMs and suppliers, out sourcing machining process – Cloud based manufacturing of parts, Vendor selection and supply chain management in cloud environment

Factors affecting cloud technology adoption and implementation: Benefits of cloud, Barriors and approaches of cloud adoption, various perspectives of users, developers and market teams, Data as a service, Business process as a service.

UNIT-IV

Sustainable manufacturing system, product design, manufacturing – Needs of sustainability - adaption of sustainability factors in product development- manufacturing requirement, strategy, domain for production paradigm, Re use, Recycle, Remanufacture for sustainability- Lifecycle sustainable information management. Augmented reality.

UNIT-V

Cloud based integrated systems for design and manufacturing – collaborative cloud based systems - visualization information sharing – Designing by service for collaborative product development – Real time work in progress management- modeling for operational information exchange network

References :

1. Weidong Li , Jorn Mehnen, ‘Cloud Manufacturing Distributed computing technologies for global and sustainable manufacturing , Springer New York

2. Stark, J., Product Lifecycle Management - 21st Century Paradigm for Product Realization, Springer-Verlag, London, 2005

ME106	ADDITIVE MANUFACTURING TECHNOLOGIES AND APPLICATIONS					
(Program Elective-IV)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		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:

CO's	Description	Blooms Level
CO1	Interpret the features of Additive Manufacturing and compare it with conventional CNC Technology	L2
CO2	Illustrate the working principle, advantages, limitations and applications of various Additive Manufacturing Technologies and Rapid Tooling systems	L2
CO3	Interpret various types data formats and STL file errors used in AM and identify the role of Topology optimization in AM	L3
CO4	Analyze the features of different types of software's used in 3D Printing	L4
CO5	Applythe knowledge of various AM technologies for developing new and innovative applications	L3

Program Articulation Matrix

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

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

VatPhotopolymerization 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. Chee Kai Chua and Kah Fai Leong, "3D Printing and Additive Manufacturing Principles and Applications" Fifth Edition, World Scientific Publications, 2017
2. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", Springer, Second Edition, 2010.
3. Frank W.Liou, "Rapid Prototyping & Engineering Applications", CRC Press, Taylor & Francis Group, 2011.
4. Rafiq Noorani, **"**Rapid Prototyping: Principles and Applications in Manufacturing", John Wiley &Sons, 2006.
5. NPTEL Course on Rapid Manufacturing. https://nptel.ac.in/courses/112/104/112104265/

ME414	ADVANCED MANUFACTURING TECHNIQUES					
(Program Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

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

- To know the fundamentals of advanced manufacturing techniques.
- To understand the working principle, advantages, limitations and applications of various advanced manufacturing techniques.
- To learn principle and applications of advanced machining techniques.

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

CO's	Description	Blooms Level
CO1	Illustrate the importance and have knowledge of Unconventional machining	L2
CO2	To understand the working principles of various Non-traditional methods in machining	L2
CO3	Analyze the various unconventional machining and improve its performance	L4
CO4	Select the corresponding unconventional method for machining a product.	L1
CO5	Analyze the high speed machining and improve its performance	L3

Program Articulation Matrix

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

UNIT-I

Introduction: 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.

UNIT-II

Thermal Metal Removal Process: Electric discharge machining Principle and operation – mechanism of metal removal, basic EDM circuitry-spark erosion. Analysis of relaxation type of circuit, material removal rate in relaxation circuits- critical resistance- parameters in RC Circuit-Dielectric fluids- flushing-Electrodes, surface finish. Applications. **Wire EDM** principle and operation. Wire materials, wire tension and its parameters. Applications.

UNIT-III

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 - dynamics of ECM process-Hydrodynamics of ECM process-polarization. Tool Design-advantages and disadvantages - applications. Electro Chemical Grinding-Electro Chemical honing, electrochemical deburring.

UNIT-IV

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. **Ion Beam Machining (IBM)**: Introduction-mechanism of metal removal and associated equipment-process characteristics and applications. **Plasma Arc Machining (PAM)**: Introduction-Plasma-generation of Plasma and equipment, mechanism of metals removal, PAN parameters-process characteristics - type of torches, applications.

UNIT-V

High speed Machining: 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.
Dry and Near-dry Machining: Environmental Impact, Dry Machining, Near-dry Machining, Reducing Coolant Use. **Practical Applications:** Precision Hard Machining, Machining Compacted Graphite Iron, Precision Roughing, Advanced Milling Operations, Machining with Multi-cut Tools.

Suggested Reading:

1. New Technology- Institution of Engineers - Bhattacharya - India
2. Production Technology - HMT - Tata McGraw Hill - ISBN-10;
3. Modern Manufacturing Method - Adithan - New Age International (P) Limited
4. Modern Machining Processes - P.K. Mishra - Narosa Publishing House, New Delhi, 1997.
5. Advanced Methods of Machining –J.A. McGeough –Springer, New Delhi-2011.
6. Introduction to Micro Machining -VK Jain-Narosa Publishing House, New Delhi.
7. Dale Mickelson, Hard Milling and High Speed Machining, Industrial Press Inc, United States, 2007

ME104	PRODUCT DESIGN AND PROCESS PLANNING					
(Program Elective-V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		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

CO's	Description	Blooms Level
CO1	Identify and analyze the product design and development processes in manufacturing industry	L2
CO2	Perform function analysis to improve the value of the product by value Engineering, estimate the cost of the product and be familiar with the Intellectual Property rights.	L5
CO3	Suggest an appropriate manufacturing process for a given product using product design rules of various manufacturing process	L4
CO4	Illustrate the importance of ergonomics in the design of new products	L2
CO5	Comprehend the role of computer in product design, Manufacturing and Management	L2

Program Articulation Matrix

Course outcome	Program outcome				
	PO1	**PO2**	**PO3**	**PO4**	**PO5**
CO1	3		2	2	2
CO2	3	1	3	3	3
CO3	3		3	3	2
CO4	3		2	2	3
CO5	3		3	2	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'sProduct 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) Procedure of value analysis

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 inproduct 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, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
2. Karl T Ulrich, Steven D Eppinger, Product Design & Development, Tata McGrawhill New Delhi 2003.
3. Mahajan, M. Industrial Engineering and Production Management, DhanpathRai& Co., 2000.
4. Anil Kumar Mukhopadhyaya, Value Engineering Mastermind- From Concept to Value Engineering Certification, SAGE Publications Ltd, 2009.

ME415	WORK SYSTEM DESIGN					
(Program Elective-V)						
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives:

- To learn the fundamentals of Work System Design
- To know the concepts of works study,
- To understand the building blocks in the implementation stage and post development stage of systems engineering.

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

CO's	Description	Blooms Level
CO1	Summarize the basics of Work System Design	L2
CO2	Recognise the importance of work study and method study in works system design	L1
CO3	Solve problems using various Work Measurement Techniques	L3
CO4	Determine the time standards from standard data	L3
CO5	Identify the role of ergonomics in the implementation of work system design	L4

Program Articulation Matrix

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

Work System Design: Introduction, Introduction and Concept of Productivity, Measurement of Productivity, Productivity Measures, Productivity Measurement Models, Factors Influencing Productivity, Causes of Low Productivity, Productivity Measurement Models, Productivity Improvement Techniques, Numerical Problems on productivity, Case study on productivity.

Unit II

Work Study: Basic Concept, Steps Involved in Work Study, Concept of Work Content, Techniques of Work Study, Human Aspects of Work Study. Method Study: developing methods – operation analysis, tools for method analysis , flow process macro analysis, operation – micro analysis, therbligs, multiple activity chart, motion & micro motion study, graphic tools. Method study in office

Unit III

Work Measurement: Basic Concept, Techniques of Work Measurement, Steps Involved in Time Study, Time Study Equipment, Performance Rating, Examples, Allowances, Computation of Standard Time, Numerical Computation of Standard Time, Case Study.

Unit IV

Applied Work Measurement: Methods time measurement (MTM), Work sampling –Determining time standards from standard data and formulas -Predetermined motion time standards –work factor system –methods time measurement, Analytical Estimation, Measuring work by physiological methods –heart rate measurement –measuring oxygen consumption–establishing time standards by physiology methods.

Unit V

Ergonomics practices – 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, Man-Machine Systems, Case Study of Office Chair, Case Tower Crane Cabin, Car Seat, Computer System, Assembly Line Worker.

Suggested Reading:

1. Benjamin W.Niebel,(2009) " *Motion and Time Study*", (9th ed), Richard, D. Irwin Inc
2. Barnes, R.M,(2002) "*Motion and Time Study*", John Wiley
3. (2001) "*Introduction to work study*",(3rd ed), ILO, Oxford & IBH publishing
4. Bridger R.S,(2008) "*Introduction to Ergonomics*", McGraw Hill

ME416	**TOTAL QUALITY MANAGEMENT**					
(Program Elective-V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

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

1. Develop quality environment of the organization.
2. Describe the TQM approach for manufacturing/service organization in length.
3. Categorise various Quality terms like Tolerance and Variability, PDCAcycle,Crosby's10 points and Deming's14Points**.**
4. Identify international and national Quality awards

UNIT-I

Evolution of Quality - Historical Perspective, Basic Concepts of Quality, Vision, Mission and Objectives of an Organization, Corporate Structure in an Organization and Role of Quality. Quality Planning, Quality By Design, Quality Costs and Cost of Failure, Waste Control, How Quality Benefits Business.

UNIT-II

Quality and Competitiveness in Business, Zero Defects and Continuous Improvement, Role of Leadership and Commitment in Quality Deployment, Team Building, Motivation and Rewards, Total Employee Empowerment, Quality Functions - Measurement, Inspection, Testing, Calibration and Assurance.

UNIT-III

Design Control and Conformity, Tolerance and Variability, PDCA Cycle, Juran Trilogy, Crosby's 10 points and Deming's 14 Points Customers Requirements, Customer-Supplier and Chain Links, Establishing Customer Focus-Customer, Satisfaction, Measurement and Customer Retention

UNIT-IV

Product Liability, Total Quality Concepts and CWQC, Difference in Western And Japanese Approach of TQM, Basic Philosophy and Fundamental Models of TQM, Total Quality and Ethics

UNIT-V

Internal Politics and Total Quality Management, Quality Culture, Education and Training Implementing Total Quality Management - An Integrated System Approach Total Preventive Maintenance. Self-Assessment, International/National Quality Awards: Malcolm Baldridge Award, Deming Prize, European Award, Rajeev Gandhi Award, CII Exim Award, Jamna Lal Bajaj Award, Golden Peacock Award

Suggested Reading:

1. Total Quality Management by N.V.R Naidu, G. Rajendra New Age international,
2. First Edition,Jan 2006
3. Total Quality Management by R.S Naagarazan ,New Age international,3e, 2015

4. Quality Control & Application by B. L. Hanson & P. M. Ghare, Prentice Hall of India, 2004.
5. Total Quality Management by V.S Bagad Technical Publications, First Edition, Jan 2008
6. Total Quality Management by S. Rajaram Dreamtech Press, First Edition, Jan 2008

ME132	MANUFACTURING OF NON-METALLIC PRODUCTS					
(Program Elective-V)						
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		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**
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

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, 2nd 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 2nd edtion, John Wiley & Sons publishers, 2004.
5. ASM Handbook, Vol. 21 Composites, 2001 Lubin, Handbook of Composites, Springer,1st Edition, 1982.

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

Course Objectives :	
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

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Apply fundamental knowledge of engineering in rehabilitation
CO-2	Apply analytical skills to assess and evaluate the need of the end-user
CO-3	Develop self-learning initiatives and integrate learned knowledge for problem solving
CO-4	Understand the basics of robotics and apply their principles in developing prosthetics
CO-5	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**
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 to Rehabilitation Engineering, Measurement and analysis of human movement, Disability associated with aging in the workplace and their solutions, clinical practice of rehabilitation engineering.

Unit – II
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., *Rehabilitation Engineering,* CRC Press, 1995.
2	Ballabio E., et al., *Rehabilitation Technology*, IOS Press, 1993.
3	Rory A Cooper, Hisaichi Ohnabe, Douglas A. Hobson, *Series in medical physis and biomedical engineering: An introduction to rehabilitation engineering*, Taylor and Francis Group, London, 2007.
4	Joseph D. Bronzino *The biomedical engineering handbook -biomedical engineering fundamentals*, 3rdEd., CRC Press, Taylor & Francis Group, London, 2006.

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

Course Objectives :	
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.

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Interpret the working principle and operating procedure and applications of X-ray equipment.
CO-2	Understand the image reconstruction techniques and applications of CT.
CO-3	Summarize the image acquisition and reconstruction techniques in MRI.
CO-4	Comprehend the working principle, modes and medical applications of ultrasound imaging.
CO-5	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**
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

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

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

Course Objectives :	
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 judicial 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

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

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

Unit – I
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.

Unit – II

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.

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

Course Objectives :	
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.

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

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 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.

Unit – II

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.

Unit – III
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.

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

Course Objectives :	
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

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

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 to Business Analytics: 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	https://onlinecourses.nptel.ac.in/noc18-mg11/preview
2	https://nptel.ac.in/courses/110105089/

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

Course Objectives :	
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

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

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
Embedded Systems Design Strategies: Micro Controller, DSP, FPGA, Introduction to Arduino (Micro controller Board), Components of Arduino, Architecture and Pin Configuration of ATMega328, Ports of ATMega328.

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

Unit – III
Real Time Programming: Interfacing Key Pad, 7-segment display, LCD, Interfacing Sensors,

Interfacing Stepper Motor**,** USB programming

Unit – IV
FPGA Based Embedded Design: FPGA Design flow, Introduction to Verilog HDL**,** Basic building blocks, Data types of Verolog HDL, Behavioral Modelling, Data Flow Modelling, Structural Modelling, Hierarchal 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 Sate 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	www.arduino.cc
2	www.learn.sparkfun.com/tutorials/arduino

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

Course Objectives :	
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.

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

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

Unit – I

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

Unit – II

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

Unit – III

Biomass Gasification: 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.

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

Course Objectives :	
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

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

Unit – I
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.

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

Course Objectives:	
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.

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

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

Unit – I
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.

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

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

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

Unit – V
Queuing models - 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, 10thEdition, 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,

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

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

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

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.

OE 943 ME	**INDUSTRIAL SAFETY**					
	(OPEN ELECTIVE)					
Pre-requisites			**L**	**T**	**P**	**C**
			3	-	-	3
Evaluation	**SEE**	60 Marks	**CIE**		40 Marks	

Course Objectives :	
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

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

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

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	1. Winterkorn, Hans, "Foundation Engineering Handbook", Chapman & Hall London

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

Course Objectives :	
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.

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

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

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

Unit – II

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 :

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

1. *Understand the purpose of doing mini project*
2. *Learn the resources available at the college and outside for pursuing project*
3. *Importance of literature review*
4. *Learn to select appropriate software and procedure*
5. *Learn to document results and arrive at required conclusions*

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	*Identify engineering problems reviewing available literature*
CO-2	*Study different techniques used to analyze complex systems.*
CO-3	*Use related techniques and software's for solving the problem*
CO-4	*Interpret the results and arrive at the relevant conclusions.*
CO-5	*Document the findings as a technical report with proper references*

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

Guidelines

1. Guide allocation will be done at the beginning of the semester. Identification of mini project work 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.

ME 452	COMPUTATIONAL LAB FOR TOOL DESIGN					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	50		

Course outcomes

1. Able to solve basic problems using Matlab
2. Able to install and solve basic engineering problems using python software
3. Able to implement matlab and python for real time projects
4. Use necessary tools to analyze practical systems for both static and dynamic conditions
5. Analyze, design, simulate, and experimentally validate systems while taking into account practical limitations of operations

MATLAB programs

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

Python Programming

1. Running Python scripts
2. Using Python as a calculator
3. Compute the value of PI
4. Computing trigonometric functions, arrays, strings, functions, methods, conditional expressions, loops, lists, modules,
5. Working with data: lists, sorting, tuples, sets, files, comprehensions, dictionaries
6. Woking with modules, object oriented programming (state, classes, objects, inheritance, errors, exceptions, iterators, generators)
7. Working with functional programming: recursion, higher order functions, decorators, exec, eval
8. Writing code for simple manufacturing processes
9. Solving optimization methods like Genetic algorithms
10. Solving problems on statistics

ME453	DESIGN SIMULATION LAB					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	2	1
Evaluation	**SEE**	-	**CIE**	50		

Course outcomes: on Completion the student should be able to

1. Understand the significance of stress analysis for various load conditions in tool design.
2. Understand the thermal behavior and application of heat transfer in moulds and die casting dies.
3. Understand the importance of parametric design approach.
4. Understand the significance of feature base modelling and its application.
5. Communicate between design and manufacturing using 2D.

List of Exercises:

1. Design and modelling of (2D and 3D) for a simple press tool with best stock utilization.
2. Design and modelling (2D and 3D) for progressive die with best stock utilization.
3. Design and modelling (2D and 3D) for a bending tool.
4. 3D modelling of a plastic component with core and cavity extraction for a 2-plate mould.
5. Design and modelling of 2-plate mould for plastic part using standard-mould base.
6. 3D modelling of a plastic component with shrinkage, cavity and core extraction for 2-plate multi impression mould.
7. Design and modelling of a die casting die for cold chamber machine.
8. Modelling of part by 3-2-1/4-2-1 principle.
9. Design and modelling of a Drill-jig.
10. Design and modelling of milling fixture.
11. Load and deflection analysis of core back plate of a mould.
12. Deflection analysis of punches.
13. Stress analysis of a bending tools.
14. Stress analysis of simply supported beam.
15. Thermal analysis of heat transfer in mould plate.

Note: To create the above exercises and appropriate design software like viz., Creo-parametric (or Unigraphics) and Ansys are consider as basic curriculum .

SEMESTER-III

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

Course Objectives :	
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

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

UNIT – I

Research Methodology: 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.

Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem

UNIT – II

Literature Survey: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet. **Literature Review**: Need of Review, Guidelines for Review, Record of Research Review.

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, 1st Edition, MJP Publishers, 2011.
3	Ratan Khananabis and Suvasis Saha, Research Methodology, 1st Edition, Universities Press, Hyderabad, 2015
4	Y.P. Agarwal, Statistical Methods: Concepts, Application and Computation, 1st Edition, Sterling Publs., Pvt., Ltd., New Delhi, 2004
5	Vijay Upagade and Aravind Shende, Research Methodology, 1st Edition, S. Chand & Company Ltd., New Delhi, 2009
6	G. Nageswara Rao, Research Methodology and Quantitative methods, 2nd Edition, BS Publications, Hyderabad, 2012.

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

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

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

Unit – I
Academic Writing: Meaning & Definition of a research paper– Purpose of a research paper – Scope – Benefits, Limitations – outcomes.

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

Unit – III
Research Methodology: Methods (Qualitative – Quantitative) Review of Literature. Criticizing, Paraphrasing & Plagiarism.

Unit – IV
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.

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, "*Research Methodology Methods and Techniques*", 4/e, New Age International Publishers.
2	Day R, "*How to Write and Publish a Scientific Paper*", Cambridge University Press, 2006
3	"*MLA Hand book for writers of Research Papers*", 7/e, East West Press Pvt. Ltd, New Delhi
4	Lauri Rozakis, Schaum's, "*Quick Guide to Writing Great Research Papers*", Tata McGraw Hills Pvt. Ltd, New Delhi.

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

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

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

Unit – I
Disaster: Classifications - Causes - Impacts including social, economical, political, environmental, health, psychosocial, etc.
Seismic performance of buildings: 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.

Unit – II
Quality assurance for concrete – 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, destructiv e, non-destructive and semi destructive testing systems, Procedure for evaluating damaged of structure.

Unit – III
Repair, Rehabilitation And Retrofitting Techniques : 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

Unit – IV
Introduction to Disasters: Hazard, Vulnerability, Resilience, Risks.-Disaster- Different types of cold wave-heat wave- droughts- floods-Effect of climate change on Processes.
Flood characteristics and forecasting: 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.
Space-time characteristics of rainfall: 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).

Unit – V
Flood Routing: Mathematics of flood routing, various methods of flood routing, Hydrologic and Hydraulic routing.
Flood mitigation: flood ways, channel improvement, evacuation and flood proofing, land management, flood plain management, estimating benefits of flood mitigation.
Flood plain adjustments and regulations: 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 Shrihkande (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.

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

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

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

Unit – 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)

Unit – II

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).

Unit – III

Role of Sanskrit in Engineering-I (Civil, Mechanical, Electrical and Electronics Engineering):

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

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

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

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

Unit – I

Human Values, Ethics and Morals: 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.

Unit – II

Value Cultivation, and Self-management: Need and Importance of cultivation of values such as Sense-of Duty, Devotion to work, Self-reliance, Confidence, Concentration, Integrity & discipline, and Truthfulness.

Unit – III

Spiritual outlook and social values: 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.

Unit – IV
Values in Holy Books: 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., *"Values & Ethics for organizations Theory and practice*", Oxford University Press, New Delhi, 1998.
2	Jaya DayalGoyandaka, "*Srimad Bhagavad Gita with Sanskrit Text*", Word Meaning and Prose Meaning‖, Gita Press, Gorakhpur, 2017.

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

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

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

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

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

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

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

Unit – V
Pranayama- Anulom and Vilom Pranayama - Nadishudhi Pranayama – Kapalabhati- Pranayama - Bhramari Pranayama - Nadanusandhana Pranayama.
Meditation techniques: Om Meditation - Cyclic meditation : Instant Relaxation technique (QRT), Quick Relaxation Technique (QRT), Deep Relaxation Technique (DRT).

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 nad Nagaratna R, "Yoga Perspective in Stress Management", Bangalore, Swami Vivekananda Yoga Prakashan

Web resource:

1	https://onlinecourses.nptel.ac.in/noc16_ge04/preview
2	https://freevideolectures.com/course/3539/indian-philosophy/11

AC 036	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS					
	(AUDIT COURSE - II)					
Pre-requisites			L	T	P	C
			2	-		0
Evaluation	SEE	60 Marks	CIE		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 :	
CO-1	*Develop their personality and achieve their highest goal of life.*
CO-2	*Lead the nation and mankind to peace and prosperity.*
CO-3	*To practice emotional self regulation.*
CO-4	*Develop a positive approach to work and duties.*
CO-5	*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 (dont'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 Bhagawat 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.

Suggested Reading:

1	"Srimad Bhagavad Gita" by Swami SwarupanandaAdvaita Ashram (Publication Department), Kolkata.
2	Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit, Sansthanam, New Delhi.

Web resource:

1	NTPEL:http://nptel.ac.in/downloads/109104115

AC 037	CONSTITUTION OF INDIA					
	(AUDIT COURSE - II)					
Pre-requisites			L	T	P	C
			2	-		0
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*The history of Indian Constitution and its role in the Indian democracy.*
2	*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.*
3	*Have knowledge of the various Organs of Governance and Local Administration.*

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

Unit – I

History of making of the Indian constitutions: History, Drafting Committee (Composition & Working). **Philosophy of the Indian Constitution**: Preamble, Salient Features.

Unit – II

Contours of Constitutional Rights and Duties 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

Unit – III

Organs of Governance": Parliament: Composition, Qualifications, Powers and Functions, Union executives : President, Governor, Council of Ministers, Judiciary, appointment and transfer of judges, qualifications, powers and functions.

Unit – IV

Local Administration - 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.

Unit – V
Election commission: 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**.**

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	http://www.nptel.ac.in/courses/103107084/Script.pdf

AC 038	PEDAGOGY STUDIES					
	(AUDIT COURSE - II)					
Pre-requisites			L	T	P	C
			2	-		0
Evaluation	SEE	60 Marks	CIE		40 Marks	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	*To present the basic concepts of design and policies of pedagogy studies.*
2	*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.*
3	*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*

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

Unit – 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.

Unit – II

Thematic Overview: Pedagogical practices followed by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

Unit – III

*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.

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

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

Course Objectives :	
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

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

Unit – I

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

Unit – II

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

Unit – III

Electronic Waste: Public Health Implications; Restriction of Hazardous Substances (RoHS) Directives in Electrical and Electronic Equipment; Materials Used in Manufacturing Electrical and Electronic Products

Unit – IV

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.

Unit – V
Cases studies: E-waste Generation, collection and recycling

Suggested Reading:

1	Electronic Waste Management and Treatment Technology, Editors: Majeti NarasimhaVara Prasad MeththikaVithanage
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): Rakesh Johri, TERI Press

ME 481	DISSERTATION PHASE-I					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	20	10
Evaluation	**SEE**	-	**CIE**	100 Marks		

Course Objectives :

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

1 *Understand the purpose of Project work*

2 *Learn the resources available at the college and outside for pursuing project*

3 *Importance of literature review*

4 *Learn to select appropriate software and procedure*

5 *Learn to document results and arrive at required conclusions*

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	*Identify suitable engineering problems reviewing available literature.*
CO-2	*Study different techniques used to analyze complex systems.*
CO-3	*Use related techniques and software's for solving the problem*
CO-4	*Interpret the results (if available) and defend work in front of technically qualified audience*
CO-5	*Document the findings as a technical report with proper references*

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

Guidelines

1. The Major Project Phase-I 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.

SEMISTER – IV

ME 481	**DISSERTATION PHASE-II**					
Pre-requisites	-		**L**	**T**	**P**	**C**
			-	-	20	10
Evaluation	**SEE**	100 Marks	**CIE**	100 Marks		

Course Objectives :

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

1 Understand the purpose of doing project work

2 Learn the resources available at the college and outside for pursuing project

3 Importance of literature review

4 Learn to select appropriate software and procedure

5 Learn to document results and arrive at required conclusions

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	*Use different Simulation models /experimental techniques/ software/ computational /analytical tools.*
CO-2	*Design and develop Simulation model/Mathematical model/ experimental set up/ equipment/ testrig.*
CO-3	*Conduct tests and draw logical conclusions from the results after analyzing them.*
CO-4	*Work in either in research environment or in an industrial environment and Conversant with technical report writing.*
CO-5	*Present and defend their work to the evaluation committee*

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

Guidelines

1. It is a continuation of Major Project Phase I work started in semester III.
2. The project work 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.
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 and a guide, co-guide etc. as decided by the Head and Faculty advisor.
8. The candidate has to be in regular contact with his guide.