KONGU ENGINEERING COLLEGE
PERUNDURAI ERODE – 638 060
(Autonomous)

VISION

To be a centre of excellence for development and dissemination of knowledge in Applied Sciences, Technology, Engineering and Management for the Nation and beyond.

MISSION

We are committed to value based Education, Research and Consultancy in Engineering and Management and to bring out technically competent, ethically strong and quality professionals to keep our Nation ahead in the competitive knowledge intensive world.

QUALITY POLICY

We are committed to

- Provide value based quality education for the development of students as competent and responsible citizens.
- Contribute to the nation and beyond through research and development
- Continuously improve our services

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

To be a centre of excellence for development and dissemination of knowledge in Mechanical Engineering for the Nation and beyond.

MISSION

Department of Mechanical Engineering is committed to:

MS1: Establish itself as an excellent academic centre through expert pedagogical methods and modern laboratories to produce world class mechanical engineers.

MS2: Disseminate knowledge through seminar, conferences and continuing education programs.

MS3: Make tie-ups with industries, research centres and renowned institutions to synergize the benefit.

MS4: Contribute towards the upliftment of the society.

2018 REGULATIONS
PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Post Graduates of M.E. CADCAM will

PEO1: Practice CADCAM in the general stems of design and development of engineering products.

PEO2: Habituate continuous learning and carryout research and development in science, engineering and technology that support career growth.

PEO3: Exhibit ethical code of conduct in a professional manner to solve real-time multidisciplinary engineering design problems.

MAPPING OF MISSION STATEMENTS (MS) WITH PEOs

MS\PEO	PEO1	PEO2	PEO3
MS1	3	3	3
MS2	2	3	2
MS3	2	3	2
MS4	1	1	2

1 – Slight, 2 – Moderate, 3 – Substantial

PROGRAM OUTCOMES (POs)	
Engineering Post Graduates will be able to:	
PO1:	carry out research /investigation and development work to solve practical problems.
PO2:	write and present a substantial technical report/document.
PO3:	use of modern engineering techniques, skills and tools for computerized design and manufacturing of engineering products and services.

MAPPING OF PEOs WITH POs AND PSOs

PEO\PO	PO1	PO2	PO3
PEO1	3	3	3
PEO2	3	3	3
PEO3	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial

CURRICULUM BREAKDOWN STRUCTURE UNDER REGULATION 2018

Curriculum Breakdown Structure(CBS)	Curriculum Content (% of total number of credits of the program)	Total number of contact hours	Total number of credits
Program Core(PC)	47.22	600	34
Program Electives(PE)	25	270	18
Project(s)/Internships(PR)/Others	27.78	600	20
		Total	**72**

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 060
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M.E. DEGREE IN CADCAM

CURRICULUM

(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – I

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
18AMC11	Applied Mathematics	3	1*	2*	4	50	50	100	PC
18EDT11	Finite Element Method	3	1	0	4	50	50	100	PC
18EDT12	Applied Materials Engineering	3	0	0	3	50	50	100	PC
18CCC11	Computer Applications in Design	3	0	2	4	50	50	100	PC
18MTC11	Computer Numerically Controlled Machines	3	0	2	4	50	50	100	PC
18GET01	Introduction to Research	3	0	0	3	50	50	100	PC
	Practical								
18EDL11	Design and Analysis Laboratory	0	0	2	1	100	0	100	PC
	Total				**23**				

*Alternate week

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

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(Autonomous)

M.E. DEGREE IN CADCAM

CURRICULUM
(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – II

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
18EDT21	Optimization Techniques in Design and Manufacturing	3	0	0	3	50	50	100	PC
18CCT21	Machining Processes and Analysis	3	1	0	4	50	50	100	PC
18CCT22	Micro and Nano Manufacturing Processes	3	0	0	3	50	50	100	PC
	Elective - I	3	0	0	3	50	50	100	PE
	Elective - II	3	0	0	3	50	50	100	PE
	Elective - III	3	0	0	3	50	50	100	PE
	Practical								
18CCL21	CAM Laboratory	0	0	2	1	100	0	100	PC
18CCP21	Mini Project	0	0	4	2	100	0	100	PR
	Total				**22**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 060
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M.E. DEGREE IN CADCAM

CURRICULUM
(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – III

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Theory/Theory with Practical								
	Elective - IV	3	0	0	3	50	50	100	PE
	Elective - V	3	0	0	3	50	50	100	PE
	Elective - VI	3	0	0	3	50	50	100	PE
	Practical								
18CCP31	Project Work Phase I	0	0	12	6	50	50	100	PR
	Total				**15**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

KONGU ENGINEERING COLLEGE, PERUNDURAI, ERODE – 638 060
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M.E. DEGREE IN CADCAM

CURRICULUM
(For the candidates admitted from academic year 2018-19 onwards)

SEMESTER – IV

Course Code	Course Title	Hours / Week			Credit	Maximum Marks			CBS
		L	T	P		CA	ESE	Total	
	Practical								
18CCP41	Project Work Phase II	0	0	24	12	50	50	100	PR
	Total				**12**				

CA – Continuous Assessment, ESE – End Semester Examination, CBS – Curriculum Breakdown Structure

Total Credits: 72

LIST OF PROFESSIONAL ELECTIVES						
Course Code	Course Title	Hours/Week			Credit	CBS
		L	T	P		
SEMESTER II						
18EDE02	Mechanical Behaviour of Materials	3	0	0	3	PE
18EDE05	Designing with Newer Materials	3	0	0	3	PE
18EDE07	Advanced Tool Design	3	0	0	3	PE
18EDE08	Design of Material Handling Equipment	3	0	0	3	PE
18MTE01	Fluid Power System Design	3	0	2	4	PE
18MTE04	Factory Automation and CIM	3	0	0	3	PE
18MTE06	Metrology and Computer Aided Inspection	3	0	0	3	PE
18MTC21	Robotics Engineering	3	0	2	4	PE
18CCE01	Computer Aided Process Planning	3	0	0	3	PE
18CCE02	Safety in Engineering Industry	3	0	0	3	PE
18CCE03	Precision Engineering	3	0	0	3	PE
18CCE04	Design for Manufacture and Assembly	3	0	0	3	PE
SEMESTER III						
18EDE10	Instrumentation and Measurements	3	0	0	3	PE
18EDE12	Productivity Management and Reengineering	3	0	0	3	PE
18MTT13	Sensors and Instrumentation	3	0	0	3	PE
18MTE12	Autonomous Mobile Robotics	3	0	2	4	PE
18MTE13	MEMS Design	3	0	0	3	PE
18MTE14	Machine Tool Control and Condition Monitoring	3	0	0	3	PE
18MTE16	Additive Manufacturing	3	0	0	3	PE
18CCE05	Product Data Management	3	0	0	3	PE
18CCE06	Modeling and Analysis of Manufacturing Systems	3	0	0	3	PE
18CCE07	Metrology and Non Destructive Testing	3	0	0	3	PE
18CCE08	Reliability Engineering	3	0	0	3	PE
18CCE09	Integrated Process and Product Development	3	0	0	3	PE

KEC R2018: SCHEDULING OF COURSES – ME CAD/CAM

Sem.	Theory/ Theory cum Practical / Practical							Internship & Projects	Special Courses	Credits
	1	2	3	4	5	6	7	8	9	
I	18AMC11 Applied Mathematics (PC-3-1*-2*-4)	18EDT11 Finite Element Method (PC-3-1-0-4)	18EDT12 Applied Materials Engineering (PC-3-0-0-3)	18CCC11 Computer Applications in Design (PC-3-0-2-4)	18MTC11 Computer Numerically Controlled Machines (PC-3-0-2-4)	18GET01 Introduction to Research (PC-3-0-0-3)	18EDL11 Design and Analysis Laboratory (PC-0-0-2-1)			23
II	18EDT21 Optimization Techniques in Design and Manufacturing (PC-3-0-0-3)	18CCT21 Machining Processes and Analysis (PC-3-1-0-4)	18CCT22 Micro and Nano Manufacturing Processes (PC-3-0-0-3)	Professional Elective - I (PE-3-0-0-3)	Professional Elective - II (PE-3-0-0-3)	Professional Elective - III (PE-3-0-0-3)	18CCL21 CAM Laboratory (PC-0-0-2-1)	18CCP21 Mini Project (PR-0-0-4-2)		22
III	Professional Elective - IV (PE-3-0-0-3)	Professional Elective - V (PE-3-0-0-3)	Professional Elective - VI (PE-3-0-0-3)					18CCP31 Project work Phase I (PR-0-0-12-6)		15
IV								18CCP41 Project work Phase II (PR-0-0-24-12)		12

Total Credits: 72

18AMC11 APPLIED MATHEMATICS

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	1*	2*	4

Preamble	This course will help the students to identify, formulate and solve problems in mechanical engineering using mathematical tools such as probability, transforms and numerical techniques.
Prerequisites	Probability, Calculus, Laplace and Fourier Transform.

UNIT – I **9**

Random Variables and Probability Distributions: Random variable – Probability mass function – Probability density function – Moments – Moment generating functions – Discrete distributions – Binomial distribution – Poisson distribution – Geometric distribution – Continuous distributions - Uniform distribution – Exponential distribution – Normal distribution.

UNIT – II **9**

Two Dimensional Random Variables: Joint distributions – Marginal and conditional distributions - Covariance – Simple linear correlation – Rank Correlation – Linear Regression.

UNIT – III **9**

Calculus of Variations: Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries – Isoperimetric problems - Direct methods : Ritz and Kantorovich methods.

UNIT – IV **9**

Transform Methods: Laplace transform methods: Solution of one-dimensional wave equation - Solution of one-dimensional heat equation – **Fourier transform methods:** Solution of Diffusion equation – Solution of one-dimensional wave equation – Solution of Laplace equation.

UNIT – V **9**

Numerical Solution of Partial Differential Equations: Solution of one dimensional wave equation – Solution of diffusion equation – Explicit and implicit methods – Solution of Elliptic equation: Solution of Laplace equation – Solution of Poisson equation.

List of Experiments:

1. Finding probability using discrete distributions
2. Identifying probability by means of continuous distributions
3. Determine the marginal and conditional distributions
4. Correlation and Regression lines
5. Finding extremum of a functional
6. Integrals involving more than one independent variable
7. Finding solution of the functional.
8. Solution of Parabolic and Hyperbolic equations by Laplace transform techniques
9. Solution of Laplace equation by Fourier Transform
10. Numerical solution of wave equation
11. Solution of Laplace equation by numerical technique
12. Numerical solution of Poisson's equation

Lecture:45, Tutorial & Practical:15, Total: 60

REFERENCES:

1. Richard Johnson, Miller & Freund's, “Probability and Statistics for Engineers”, 9th Edition, Pearson Education, 2016.
2. Gupta A.S., “Calculus of Variations with Applications”, 12th Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2015.
3. Sankara Rao K., “Introduction to Partial Differential Equations”, 3rd Edition, PHI Learning Pvt. Ltd., 2011.
4. Curtis F. Gerald, Patrick O.Wheatley, “Applied Numerical Analysis”, 7th Edition, Pearson Education India, 2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply probabilistic concepts in engineering problems	Applying (K3)
CO2:	measure the relationship between variables	Applying (K3)
CO3:	solve variational problems that appear in engineering design	Applying (K3)
CO4:	apply Laplace and Fourier transforms to solve initial and boundary value problems in Partial differential equations	Applying (K3)
CO5:	use numerical techniques to solve partial differential equations	Applying (K3)
CO6:	apply MATLAB to identify the probability and association between random variables	Applying (K3), Manipulation (S2)
CO7:	use MATLAB to handle engineering problems involving functional and Partial differential equations	Applying (K3), Manipulation (S2)
CO8:	use MATLAB to find numerical solution of PDE	Applying (K3), Manipulation (S2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1			1
CO2			1
CO3	1		1
CO4	1		2
CO5	3		2
CO6	1		1
CO7	3		2
CO8	1		2

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom’s Taxonomy

* Alternate Week

18EDT11 FINITE ELEMENT METHOD

(Common to Engineering Design & CADCAM Branches)

L	T	P	Credit
3	1	0	4

Preamble	To familiarize the fundamental concepts of finite element analysis with the principles involved in discretization and to assemble stiffness matrices and force vectors for simple/advanced elements.
Prerequisites	Strength of Materials

UNIT – I **9**

One Dimensional Applications: Historical Background - Weighted Residual Methods - Basic Concept of FEM - Variational Formulation - Ritz Method - Finite Element Modelling - Element Equations - Linear and Quadratic Shape functions - Bar and Beam Elements - Galerkin"s method - Application of structural bar and heat transfer.

UNIT – II **9**

Two Dimensional Scalar Variable Applications: Basic boundary value problems in two dimensions - Constant Strain Triangular element - Higher order elements – Poisson's and Laplace's Equation - Weak Formulation - Element Matrices and Vectors - Load consideration: Point load and Pressure - Plane stress and Plane strain conditions. Two dimensional heat transfer: Finite element equation - Potential energy approach - Conduction - Side and face convection - Internal heat generation. Application of Structural and Heat transfer.

UNIT – III **9**

Two Dimensional Vector Variable Problems: Introduction to Axi-symmetric Formulation - linear element - Elemental Element Matrices and Vectors - Load Consideration - Application of Structural and Heat Transfer Problems - Application of Plane Trusses.

UNIT – IV **9**

Iso-Parametric Formulation: Natural Co-ordinate Systems - Lagrangian Interpolation Polynomials - Isoparametric Elements - Formulation - Numerical Integration - Gauss Quadrature - One and two dimensional Integration - Rectangular elements - Serendipity elements - Finite element modeling - Illustrative Examples.

UNIT – V **9**

Structural Dynamics and Refinements: Dynamic Analysis - Equation of Motion – Mass and damping matrices - Free vibration analysis - Natural frequencies of Longitudinal, Transverse and Torsional vibration - Introduction to transient field problems. Refinement techniques - h and p elements.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Rao Singiresu S., "The Finite Element Method in Engineering", 6th Edition, Butterworth-Heinemann, 2017.
2. Reddy J.N., "An Introduction to the Finite Element Method", 3rd Edition, McGraw Hill, Edition, 2009.
3. Logan D.L., "A First Course in the Finite Element Method", 6th Edition, Cengage Learning, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	comprehend the finite element concepts and derive the element matrix equation for solving one dimensional structural problems used for designing engineering components	Analyzing (K4)
CO2:	compute the results for a 3D domain using simple two dimensional assumptions for different applications	Analyzing (K4)
CO3:	solve and analyze the engineering problems using axisymmetric assumptions	Analyzing (K4)
CO4:	comprehend the effective usage of isoparametric elements and numerical integration techniques used in FEM	Analyzing (K4)
CO5:	solve the structural dynamic problems in various applications	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	1	3
CO2	2		2
CO3	2		2
CO4	2		2
CO5	2		2

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18EDT12 APPLIED MATERIALS ENGINEERING

(Common to Engineering Design & CADCAM Branches)

L	T	P	Credit
3	0	0	3

Preamble	The course deals with the study on structure –property relationship of ferrous metals, analysis on their morphological and technical characteristics, purpose of heat treatment and related techniques.
Prerequisites	Fundamentals of Material Science and Engineering

UNIT – I **9**

Introduction of Physical Metallurgy: Concept of phase diagram - phases and micro constituents in steels and cast irons - Equilibrium and non-equilibrium cooling of various Fe-C alloys - Effects of alloying elements and cooling rate on structure and properties of steels and cast irons.

UNIT – II **9**

Introduction to Heat Treatment and Specifications: Time Temperature Transformation (TTT) diagram and Continuous Cooling Transformation (CCT) diagram - hardenability, measurement, annealing - normalizing - hardening and tempering - heat treatment furnaces - atmospheres - quenching media - case hardening techniques. Types of steels: plain carbon steels - alloy steels - tool steels - stainless steels - types of cast iron – compositions - properties and applications.

UNIT – III **9**

Characterization of Materials: Stereographic projections - X-ray diffraction - Crystal structure and phase identification - Residual stress measurement and other applications. Scanning Electron Microscopy (SEM) – Optics and performance of SEM - Image interpretation - Crystallographic information - Analytical microscopy. Transmission Electron Microscopy (TEM) - Construction and operation of TEM - Electron diffraction - Image interpretation.

UNIT – IV **9**

Corrosion Engineering: Degradation of Materials: Oxidation - Corrosion and wear. Basics of thermodynamics and kinetics of oxidation and corrosion - Pourbaix diagram – Polarization - Different types of corrosion - Atmospheric, galvanic, pitting, crevice corrosion, intergranular and de-alloying - Stress corrosion cracking - Season cracking - Hydrogen damage and radiation damage - Hydrogen embrittlement - Corrosion rate measurement.

UNIT – V **9**

Metallurgical Failure Analysis and Plastic Deformation: Stages of failure analysis - Classification and identification of various types of fracture. Overview of fracture mechanics - Characteristics of ductile and brittle fracture. General concepts - Fracture characteristics revealed by microscopy - Factors affecting fatigue life – Creep - Stress rupture - Elevated temperature fatigue - Metallurgical instabilities - Environmental induced failure - Some case studies on failures - Basics of plastic deformation: Mohr's circle - yield theories - plastic stress - strain relationship - mechanical working - work hardening.

Total: 45

REFERENCES:

1. Avner, S. H., "Introduction to Physical Metallurgy", 2nd Edition, McGraw Hill, 2017.
2. Philips V. A., "Modern Metallographic Techniques and their Applications", Wiley Interscience, 1972.
3. Fontana. M.G., "Corrosion Engineering", 3rd Edition, Tata McGraw Hill, 2005.
4. Colangelo V.J. and Heiser F.A., "Analysis of Metallurgical Failures", John Wiley and Sons Inc. New York, USA, 1987.
5. Hosford W.F. and Caddell R.M., "Metal Forming Mechanics and Metallurgy", Printice Hall, 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	demonstrate the microstructures of steels and cast irons	Analyzing (K4)
CO2:	apply heat treatment processes for various applications	Applying (K3)
CO3:	determine the microstructure for utilizing the material characterization	Applying (K3)
CO4:	analyze the causes and impacts of corrosion	Analyzing (K4)
CO5:	solve the problems in plastic deformation of materials and to analyse the failures	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	1	1	3
CO2	3	2	3
CO3	3	2	3
CO4	3	3	3
CO5	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18CCC11 COMPUTER APPLICATIONS IN DESIGN

(Common to CADCAM & Mechatronics Branches)

(Approved Data book may be permitted)

L	T	P	Credit
3	0	2	4

Preamble	As modeling is inevitable in design process, the application of computer graphics and visual realism concepts are to be known. To develop models the knowledge on surface and solid modeling is mandatory. Basic knowledge on programming is needed to develop design program for mechanical components.
Prerequisites	Applied Mathematics, Engineering Drawing

UNIT – I **9**

Introduction to Computer Graphics: Design Process and CAD – Constraints – Computer graphics principles – Output primitives - Line and Circle drawing algorithms- Parametric equations (lines, circle) - 2 D and 3D transformation - Translation, scaling, rotation -Windowing, view ports - Clipping transformation.

UNIT – II **9**

Visual Realism and Curves: Hidden Line, Surface, Solid removal Algorithms - Shading - Coloring - RGB, HSV, HLS models - Introduction to curves - Analytical curves: line, circle and conics - Synthetic curves: Hermite cubic spline - Bezier curve and B-Spline curve - Curve manipulations.

UNIT – III **9**

Surface and Solid Modeling: Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated surface - Synthetic surfaces: Hermite bicubic surface - Bezier surface and B-Spline surface - Surface manipulations. Solid Modeling Techniques - Constructive Solid Geometry and Boundary Representation - Solid modeling systems - Parametric modeling - Creation of prismatic and revolved parts using solid modeling packages.

UNIT – IV **9**

Tolerance analysis and Mass property calculations: Assembly Modeling - Geometrical tolerance - Tolerance modeling and analysis - Mass property calculations - Curve length, Area, Volume, Mass, Moment of inertia - Mechanism simulation.

UNIT – V **9**

Computers in Design Productivity: Data Exchange formats - IGES, STEP - Reverse Engineering of components - Design optimization. Developing design programs using C for applications like design of shafts, gears etc.

List of Exercises / Experiments :

1. Creation of solid components by CSG and assemble the models to create a final assembly
2. Construction of solid models using parameters (variable quantities such as measurements) and editing the model by using its history
3. Creation of surfaces of desired shape by trimming, stitching and joining different surfaces to create a final shape model
4. Conversion of the real component into 3D CAD Model using measurement tools & CMM (coordinate measuring machine)
5. Development of design programs using C for applications like design of shafts and gears.

Lecture:45, Practical:30, Total: 75

REFERENCES:	
1.	Zeid Ibrahim, "Mastering CAD/CAM", Tata McGraw Hill, New Delhi, 2007.
2.	Hearn Donald and Baker M Pauline, "Computer Graphics", C Version, Prentice Hall Inc., 2000.
3.	Neumann William M. and Sproul Robert, "Principles of Interactive Computer Graphics", McGraw-Hill Book Co., 2001.
4.	Rao P.N., "CAD/CAM: Principles and Applications", 3rd Edition, McGraw Hill, 2010.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	develop the output primitives and demonstrate transformations by applying the mathematical concepts behind computer graphic principles	Applying (K3)
CO2:	manipulate synthetic curves with mathematical concepts and illustrate visual realism techniques	Applying (K3)
CO3:	demonstrate surface and solid modeling techniques	Applying (K3)
CO4:	perform tolerance analysis and calculate geometrical and mass properties of a model	Evaluating (K5)
CO5:	write design programs using C/Auto LISP for shaft and gears	Applying (K3)
CO6:	model the solid components by CSG, B-rep and assemble the models to develop final assembly	Applying (K3), Precision(S3)
CO7:	develop surface models of desired shape by trimming, stitching and joining different surfaces to create a final shape model	Applying (K3), Precision(S3)
CO8:	convert the real component into 3D CAD model using measurement tools and CMM	Analyzing (K4), Precision(S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	1	1	3
CO2	1	1	3
CO3	1	2	3
CO4	2	1	3
CO5	2	1	3
CO6	2		3
CO7	2		3
CO8	2		3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MTC11 COMPUTER NUMERICALLY CONTROLLED MACHINES (FROM MTS)
(Common to Mechatronics, Engineering Design & CADCAM Branches)

L	T	P	Credit
3	0	2	4

Preamble	To impart the fundamental knowledge and programming concepts of CNC machines.
Prerequisites	Nil

UNIT – I **9**

Construction Features of CNC Machines: Introduction - CNC Machine Building, Drives and Controls: Drive Mechanism, Spindle Drives, Axes drives, Feed drives, Linear Motors and Actuators, Magnetic Levitation. Power transmission elements - Spindle bearing – Arrangement and installation - Guide ways – Configuration and design, friction and anti-friction LM guide ways, Retrofitting.

UNIT – II **9**

Control Systems for CNC Machines and CAD/CAM Integration: Interfacing – Monitoring – Diagnostics – Machine data – Sources of errors - Compensations for Machine accuracy – DNC – Adaptive control CNC systems. Concepts of High speed Machining and micro machining. Networking - networking techniques, LAN, components - Graphics standards – Data exchange format, evolution - features of various interfaces GKS, IGES, DXF, PDES, STEP etc., Process planning, Computer Aided process planning (CAPP) - Variant, generative Approaches.

UNIT – III **9**

CNC Programming: Structure of CNC program, Part Program Terminology Coordinate system, G & M codes, cutter radius compensation, tool nose radius compensation, tool wear compensation, canned cycles, sub routines, mirroring features, Manual part programming for CNC turning and machining centre – APT programming for various machines in FANUC - Computer aided part programming - Post processing.

UNIT – IV **9**

Tooling System and Management: Tooling system - Interchangeable tooling system – Preset, Qualified and semi-qualified tools – Coolant fed tooling system – Modular fixturing – Quick change tooling system – Automatic head changers – Tooling requirements for Turning and Machining centers – Tool holders – Tool assemblies – Tool Magazines – ATC Mechanisms – Tool management.

UNIT – V **9**

Economics of CNC Operations and Special Purpose CNC Machines: Factors influencing selection of CNC machines - Cost of operation of CNC machines - Practical aspects of introducing CNC machines - Maintenance features of CNC machines - Preventive and other maintenance requirements. CNC grinding machines, CNC bending machines - pipe bending, CNC turret Press, CNC EDM - Wire cut EDM, CNC ECM - Electrochemical grinding machines.

List of Exercises:

1. Study of G codes and M codes for machining centre and turning centre
2. Programming and machining of given component using HMT VMC 200T
3. Programming and machining of given component using HMT CNC T70
4. Programming and machining of given component using CNC turning centre
5. Programming and simulation of given component using MASTER CAM (Lathe)

Lecture:45, Practical:30, Total: 75

REFERENCES:

1.	Michael Fitzpatrick N.E., and Arlington W.A., "Machining and CNC Technology", 3rd Edition, McGraw Hill Education, 2014.
2.	Sehrawat M.S. and Narang J.S., "CNC Machines (Computer Numerical Control)", Dhanpat Rai and Co., Pvt. Ltd., New Delhi, 2014.
3.	Alan Overby, "CNC Machining Handbook: Building, Programming and Implementation", The McGraw-Hill Companies Inc., 2011.
4.	Adithan M. and Pabla B.S., "CNC Machines", 3rd Edition, New Age International (P) Ltd., 2010.
5.	Madison J., "CNC Machining Handbook: Basic theory, Production data and Machining process", Industrial Press Inc., 2005.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	explain the basic components and mechanisms of CNC system	Understanding
CO2:	interpret the control system concepts used in CNC machine	Understanding
CO3:	formulate part programming for turning and milling processes	Creating
CO4:	select proper tooling systems and fixtures for holding the work piece	Applying
CO5:	infer the economic concepts of CNC machine and selection of special purpose CNC machine	Understanding

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	1	1
CO2	3	3	1
CO3	3	2	2
CO4	3	1	1
CO5	2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy, BT – Bloom's Taxonomy

18GET01 INTRODUCTION TO RESEARCH

(Common to Engineering and Technology Branches)

L	T	P	Credit
3	0	0	3

Preamble	To familiarize the fundamental concepts/techniques adopted in research, problem formulation and patenting. To disseminate the process involved in collection, consolidation of published literature and rewriting them in a presentable form using latest tools.
Prerequisites	Nil

UNIT – I **9**

Concept of Research: Meaning and Significance of Research: Skills, Habits and Attitudes for Research - Time Management - Status of Research in India. Why, How and What a Research is? - Types and Process of Research - Outcome of Research - Sources of Research Problem - Characteristics of a Good Research Problem - Errors in Selecting a Research Problem - Importance of Keywords - Literature Collection – Analysis - Citation Study - Gap Analysis - Problem Formulation Techniques.

UNIT – II **9**

Research Methods and Journals: Interdisciplinary Research - Need for Experimental Investigations - Data Collection Methods - Appropriate Choice of Algorithms / Methodologies / Methods - Measurement and Result Analysis - Investigation of Solutions for Research Problem - Interpretation - Research Limitations. Journals in Science/Engineering - Indexing and Impact factor of Journals - Citations - h Index - i10 Index - Journal Policies - How to Read a Published Paper - Ethical issues Related to Publishing - Plagiarism and Self-Plagiarism.

UNIT – III **9**

Paper Writing and Research Tools: Types of Research Papers - Original Article/Review Paper/Short Communication/Case Study - When and Where to Publish? - Journal Selection Methods. Layout of a Research Paper - Guidelines for Submitting the Research Paper - Review Process - Addressing Reviewer Comments. Use of tools / Techniques for Research - Hands on Training related to Reference Management Software - EndNote, Software for Paper Formatting like LaTeX/MS Office. Introduction to Origin, SPSS, ANOVA etc., Software for detection of Plagiarism.

UNIT – IV **9**

Effective Technical Thesis Writing/Presentation: How to Write a Report - Language and Style - Format of Project Report - Use of Quotations - Method of Transcription Special Elements: Title Page - Abstract - Table of Contents - Headings and Sub-Headings - Footnotes - Tables and Figures - Appendix - Bibliography etc. - Different Reference Formats. Presentation using PPTs.

UNIT – V **9**

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

TOTAL: 45

REFERENCES:

1. DePoy, Elizabeth, and Laura N. Gitlin, “Introduction to Research-E-Book: Understanding and Applying Multiple Strategies”, Elsevier Health Sciences, 2015.
2. Walliman, Nicholas, “Research Methods: The basics”, Routledge, 2017.
3. Bettig Ronald V., “Copyrighting culture: The political economy of intellectual property”, Routledge, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	list various stages in research/patenting and categorize the quality of journals	Analyzing
CO2:	formulate a research problem from published literature/journal papers	Evaluating
CO3:	write, present a journal paper/ project report using latest tools in proper format	Creating
CO4:	select suitable journal and submit a research paper	Applying

Mapping of COs with POs and PSOs

COs/POs	PO1	PO2	PO3
CO1	3	2	1
CO2	3	2	3
CO3	3	3	1
CO4	3	2	1

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18EDL11 DESIGN AND ANALYSIS LABORATORY

(Common to Engineering Design & CADCAM Branches)

L	T	P	Credit
0	**0**	**2**	**1**

Preamble	Design and analysis laboratory is the use of computer systems to aid in the creation, Modification, analysis, or optimization of a design. Analysis software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing.
Prerequisites	Strength of materials, Design of machine elements, Modeling skill, Technical drawing reading skill, Knowledge in modeling and analysis software.

List of Exercises / Experiments :

1. Modeling and Assembly of component using Creo
2. Modeling a component using Creo, Importing to ANSYS and Meshing
3. Finding shear Force and Bending Moment diagram using ANSYS APDL
4. Meshing a component using ANSYS WORKBENCH
5. Structural Analysis using ANSYS WORKBENCH
6. Non-Linear structural contact analysis of a component using ANSYS
7. Thermal Analysis of a component using ANSYS APDL
8. Modal Analysis of a structure using ANSYS APDL
9. Harmoic Analysis using ANSYS APDL
10. Coupled Field Analysis using ANSYS APDL

Total: 30

REFERENCES / MANUALS / SOFTWARES:

1. Laboratory manual

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	analyze the problem boundary conditions with various fields using analysis software	Applying (K3), Manipulation(S2)
CO2:	model and analyze the structural members with external load for different applications	Applying (K3), Precision(S3)
CO3:	analyze the non-linear structural, thermal and coupled field problems for various applications	Applying (K3), Precision(S3)
CO4:	analyze the mode shape and critical frequency of the structural component	Applying (K3), Precision(S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	3	3
CO2	3	3	3
CO3	3	3	3
CO4	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18EDT21 OPTIMIZATION TECHNIQUES IN DESIGN AND MANUFACTURING

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble	This course emphasis the application of optimization techniques, tools and methods in the field of Engineering.
Prerequisite	Fundamentals of Operation Research and Mathematical knowledge.

UNIT – I **9**

Introduction: Introduction to optimum design-global and local – Problems - General Characteristics of mechanical elements-adequate and optimum design-general principles of optimization, formulation of objective function, design constraints – Classification of optimization problem -Saddle point-Single variable optimization-Multi variable optimization with no constraints.

UNIT – II **9**

Unconstrained Optimization Techniques: Single variable and multivariable optimization with constraints, Techniques of unconstrained minimization -Golden section, pattern and gradient search methods - Interpolation methods -Quadratic function method.

UNIT – III **9**

Constrained and Advanced Optimization Techniques: Optimization with equality and inequality constraints - Indirect methods using penalty functions, Lagrange multipliers; Geometric programming-Constrained, mixed inequality and unconstrained minimization; Introduction - GA, SA and NN based on optimization - Fuzzy systems - Taguchi Technique - Parallel processing.

UNIT – IV **9**

Static Applications: Structural applications – Design of simple truss members-Reanalysis techniques Design applications -Design of simple axial, transverse loaded members for minimum cost, maximum weight - Design of shafts and torsionally loaded members – Design of springs.

UNIT – V **9**

Dynamic Applications: Optimum design of single and two degree of freedom systems, vibration absorbers. Optimum design of simple linkage mechanisms. Case study: optimization of process parameters in production operation.

Total: 45

REFERENCES:

1. Rao Singaresu S., “Engineering Optimization – Theory and Practice”, 4th Edition, New Age International Pvt. Ltd., New Delhi, 2009.
2. Kalyanamoy Deb, “Optimization for Engineering Design Algorithms and Examples”, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2012.
3. Goldberg D.E., “Genetic algorithms in search, optimization and machine”, 4th Edition, Barnen, Addison Wesley, New York, 2009.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	build an optimization problems for design and manufacturing applications	Evaluating (K5)
CO2:	compute the optimum value for unconstrained optimization problem	Evaluating (K5)
CO3:	solve the optimization problem by various techniques	Evaluating (K5)
CO4:	design the stress members and shafts using reanalysis techniques	Applying (K3)
CO5:	optimize the influencing parameters for linkages and vibratory systems	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	2	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom’s Taxonomy

18CCT21 MACHINING PROCESSES AND ANALYSIS

L	T	P	Credit
3	1	0	4

Preamble	This course provides insights of mechanics of metal quality and importance of tool nomenclature on machining process. Also, it provides the basic understanding of the thermal aspects and wear mechanisms of machining process.
Prerequisites	Fundamentals of material removal processes

UNIT – I **9**

Mechanics of Cutting: Chip Formation-Introduction-Types of Chips-Primary Plastic Deformation in Continuous Chip Formation-Tool-Chip Friction and Secondary Deformation-Chip Control-Burr Formation and Control Measurement of Cutting Forces and Chip Thickness –Force Components-Empirical Force Models Specific Cutting Energy-Shear Plane and Slip Line Theories for Continuous Chip Formation Shear Plane Models for Oblique Cutting-Shear Zone Models-Minimum Work and Uniqueness Assumptions-Finite Element Models-Discontinuous Chip Formation-Built-Up Edge Formation.

UNIT – II **9**

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

UNIT – III **9**

Thermal Aspects in Machining and Tool Material: Heat distribution in machining-effects of various parameters on temperature-methods of temperature measurement in machining-hot machining-cutting fluids Essential requirements of tool materials-development in tool materials-ISO specification for inserts and tool holders-tool life-conventional and accelerated tool life tests-concept of mach inability index-economics of machining.

UNIT – IV **9**

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

UNIT – V **9**

Abrasive Machining Processes: Abrasive machining processes- mechanics of grinding process, grinding wheel specification- conventional- super abrasive – grinding wheel wear- selection of grinding wheel- super finishing processes.

Lecture:45, Tutorial:15, Total: 60

REFERENCES:

1. Boothroyd D.G. and Knight W.A., “Fundamentals of machining and machine tools”, 3rd Edition, CRC Press, NewYork, 2006.
2. Shaw M.C., “Metal cutting principles”, 2nd Edition, Oxford University Press, 2012.
3. Bhattacharya A., “Metal Cutting: Theory and practice”, New Central Book Agency, India, 2012.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply fundamentals of metal cutting ~~as applied~~ to a machining processes	Applying (K3)
CO2:	select suitable nomenclature for a cutting tool	Applying (K3)
CO3:	examine the influence of temperature in cutting tool material	Analyzing (K4)
CO4:	interpret reason for tool failure	Evaluation (K5)
CO5:	recommend suitable machining process for finishing operation	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3		2
CO2	3		2
CO3	3		2
CO4	3		2
CO5	3		2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCT22 MICRO AND NANO MANUFACTURING PROCESSES

L	T	P	Credit
3	0	0	3

Preamble	The course provides the details about Micro manufacturing and Micro machining. Also it describes the nano finishing, micro joining and micro manufacturing processes.
Prerequisites	Fundamentals of manufacturing processes.

UNIT – I **9**

Micro Manufacturing: Introduction - Miniaturization and Applications -Classification –Subtractive Processes -Traditional Micromachining-Advanced Micromachining Processes-Nanofinishing Processes-Additive Processes-Mass Containing Processes-Microforming-Micromolding- Microcasting-Microjoining-Miscellaneous Applications-Challenges in Meso-, Micro-, and Nanomanufacturing.

UNIT – II **9**

Micromachining: Microgrinding Introduction - Types of Grinding Wheels –Machining and Grinding—A Comparison - Grindability - Grinding Mechanisms-Micro grinding—Its Definition and Applications. Advanced Micromachining: Micro- and Nano manufacturing by Focused Ion Beam-Introduction - Focused Ion Beam System (Dual Beam)-Ion–Matter Interaction –Working principles of focused iron beam.

UNIT – III **9**

Nanofinishing: Magnetorheological and Allied Finishing Processes: Introduction - Magnetorheological (MR) Fluid-Magnetorheological Finishing (MRF) - Magnetorheological Abrasive Flow Finishing (MRAFF). Magnetic Abrasive Finishing (MAF): Introduction -Working Principle of Magnetic Abrasive Finishing-Allied and Hybrid MAF Processes-Pulsating Current Magnetic Abrasive Finishing (PC-MAF).

UNIT – IV **9**

Microjoining & Microforming: Micro joining: Laser Micro welding- Introduction - Laser Welding Process-Laser Welding Practice-Laser Micro welding Applications -Electron Beams for Macro and Micro welding Applications-Introduction - Description of an EBW Setup - Design Considerations of the Electron Gun Column-Electron Beams for Micro Operations. Micro forming: Micro and Nanostructured Surface Development by Nano Plastic Forming and Roller Imprinting-Introduction - Nano Plastic Forming -NPF-CRI Technique - Micro- and Nanostructured Surface Development.

UNIT – V **9**

Dimensional Metrology for Micro/Mesoscale Manufacturing: Introduction-Touch Probe Measurement - Optical Measurements-Scanning Probe Microscopy -Hybrid Processes - On-Machine Metrology.

Total: 45

REFERENCES:

1. Jain. V.K., “Micromanufacturing Processes”, CRC Press, 2013.
2. Jain.V.K., “Introduction to Micromachining”, Narosa Publishing House, 2010.
3. Mark J. Jackson, “Micro Fabrication and Nano machining”, Taylor and Francis, 2006.
4. Yi Qin, “Micro-Manufacturing Engineering and Technology”, Elsevier Publication, 2010.
5. Serope Kalpakjain, “Manufacturing Engineering and Technology”, Pearson Education, 2005.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	identify newer machining processes (Micro and Nano) and advantages over traditional machining methods	Applying (K3)
CO2:	analyze the concept, mechanism of material removal in micro manufacturing	Analyzing (K4)
CO3:	realize the principles of various nano finishing processes	Applying (K3)
CO4:	explore concepts of various micro joining and forming processes	Analyzing (K4)
CO5:	quantify the micro and nano finished component at micro/meso scale level	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3		2
CO2	3		2
CO3	3		3
CO4	3		3
CO5	3		3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCL21 CAM LABORATORY

L	T	P	Credit
0	0	2	1

Preamble	The engineering products cannot be produced by conventional machines with accuracy. In order to produce the components accurately and exactly the engineering communities depend on computer aided manufacturing processes. With the aid of automated machines, mass production and component with accurate sizes can be produced.
Prerequisites	Fundamentals of CAD/CAM.

List of Experiments:

1. Study of G codes and M codes for machining centre and turning centre.
2. Programming and machining of given component using HMT VMC 200T.
3. Programming and machining of given component using HMT VMC T70.
4. Programming and machining of given component using CNC Turning Centre.
5. Programming and simulation of given component using MASTER CAM(Lathe)
6. CNC code generation of given component using MASTER CAM (Lathe) and interfacing it to CNC turning centre.
7. CNC code generation of given component using MASTER CAM (Mill) and interfacing it to CNC turning centre.
8. Programming and machining of given component using CNC machining centre.
9. Programming and machining of given component using MASTERCAM (Milling).
10. CNC code generation of given component using Pro Manufacturing.

Total: 30

REFERENCES / MANUALS / SOFTWARES:

1. CNC Lab Manuals
2. Master CAM ,Pro Manufacturing

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	exhibit the G codes and M codes of CNC Machine	Applying (K3)
CO2:	develop, simulate and execute part program using CNC production and trainer machines	Analyzing (K4)
CO3:	simulate using CAM package and interface the developed	Applying (K3)
CO4:	simulate using MASTERCAM Milling	Applying (K3)
CO5:	develop CNC Code in Pro Manufacturing	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	2	2
CO2	3	2	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18EDE02 MECHANICAL BEHAVIOUR OF MATERIALS

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble	This course provides the necessary knowledge of behaviour under loads which is needed in manufacture and design.
Prerequisites	Fundamentals of material sciences, Fundamental of physical properties of the materials, Basic type of metal and non-metallic materials

UNIT – I **9**

Elasticity of the Materials: Analysis of stress-definition and notation of stress - equation of equilibrium - description of stress at a point- principal stresses - two and three dimensional Mohr's circles diagram. Boundary condition in terms of surface forces. Analysis of stress-strain components- description of strain at a point - compatibility equations of elasticity: Generalized Hooke's law-formulations of elastic problems - two and three dimensional Mohr"s circles diagram - strain energy.

UNIT – II **9**

Plane Stress and Plane Strain Problems: The governing differential equations - bending of narrow cantilever beam of rectangular cross section under an end load - General equations in cylindrical co-ordinates – effect of small circular holes in strained plates-stress concentration

UNIT – III **9**

Elements of the Theory of Plasticity: Introduction - flow curves-tensile test - true stress/true strain-yield criteria for ductile metals- plastic stress-strain relations. Creep definition-creep tests and properties of creep. Theories of failure.

UNIT – IV **9**

Fracture: Overview of problem of fracture and fatigue in structures-stress analysis for members with cracks-stress intensity equations- Relationship between stress intensity factor and fracture toughness. Experimental determination -K_{IC} and Kc values-effect of temperature, loading rate and plate thickness on fracture toughness.

UNIT – V **9**

Fracture Mechanics Design: Fatigue crack initiation- fatigue crack propagation under constant load and variable load - fatigue damage tolerance, Elastic - plastic fracture mechanics.

Total: 45

REFERENCES:

1. George E. Dieter, "Mechanical Metallurgy", 3rd Edition, McGraw Hill Education (India) Pvt. Ltd., 2013.
2. Wang C.T., "Applied Elasticity", McGraw-Hill, New York, 1953.
3. Barsoom M. John and Rolte T. Stanley, "Fracture and Fatigue Control in Structures", Prentice-Hall, New Jersey, 1987.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	understand the elastic behaviours of the materials.	Understanding (K2)
CO2:	analyze the problems of plane stress and strain conditions.	Analyzing (K4)
CO3:	understand the plastic behaviours of the materials.	Understanding (K2)
CO4:	implement the various fracture stress analysis under various conditions.	Analyzing (K4)
CO5:	implement the fracture mechanics and the design under various conditions	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3		2
CO2	3		3
CO3	3	2	2
CO4	3	2	2
CO5			2

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18EDE05 DESIGNING WITH NEWER MATERIALS

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble	The course deals with the study on structure – property relationship of non metals, processing techniques involved in fabrication of components and related applications.
Prerequisites	Introduction to material science and engineering

UNIT – I **9**

Modern Materials in Design and Plastics: Modern materials in design plastics composites and smart materials Polymers - classification - Thermoplastics and thermosetting plastics –structure-property relationship- Thermoforming processes - compression and transfer molding - injection molding - extrusion - blow molding - calendaring - lamination and pultrusion. Design consideration in manufacturing of plastic components

UNIT – II **9**

Rubber: Rubber - additives - applications. Stages in raw rubber and latex rubber technology-structure-property relationship -Processing of rubbers –Manufacturing techniques - tyres - belts - hoses - foot wears - cellular products - cables. Manufacture of latex based products

UNIT – III **9**

Glass: Glass - characteristics - application - glass making - Glass forming machines - hollow waresflat 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 **9**

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

UNIT – V **9**

Composites: Composites - requirements of reinforcement and matrix - Manufacturing of composites -casting - solid state diffusion - cladding – Hot Isostaic Pressing - liquid metal infiltration - liquid phase sintering - preparation of molding compounds and prepregs - hand layup method - autoclave method - filament winding method – functionally graded materials-features-processing methods-applications

Total: 45

REFERENCES:

1. Brydson J. A. and Newnes-Butterwarths, “Plastic Materials”, 8th Edition, London, 2016.
2. Barsoum M.W., “Fundamentals of Ceramics”, 2nd Edition, McGraw-Hill Co. Inc., 2002.
3. George Lubin, “Handbook of Composites”, 1st Edition, Springer, 1982.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	demonstrate the manufacturing and design aspects of plastics	Applying (K3)
CO2:	present processing properties and applications of rubber products	Applying (K3)
CO3:	demonstrate processing and applications of glasses	Applying (K3)
CO4:	demonstrate processing and applications of ceramics	Analyzing (K4)
CO5:	demonstrate processing and applications of composites	Analyzing (K4)

Mapping of COs with POs

COs/Pos	PO1	PO2	PO3
CO1	3	1	3
CO2	3	1	3
CO3	2	1	2
CO4	3	1	3
CO5	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT –Bloom's Taxonomy

18EDE07 ADVANCED TOOL DESIGN

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble	This course provides concepts and techniques for designing the elements of tool engineering and appropriate materials. Also, explore the important of press tools, jigs and fixtures and tool maintenance.
Prerequisites	Manufacturing Technology, Design for manufacture and assembly

UNIT – I **9**

Tool Design Methods: Introduction – The Design Procedure – Statement of the problem – The Need Analysis – Research and Ideation – Tentative Design Solutions – The Finished Design – Drafting and Design Techniques in Tooling drawings – Screws and Dowels – Hole location – Jig-boring practice – Installation of Drill Bushings – Punch and Die Manufacture – Electro-discharge machining – Electro-discharge machining for cavity.

UNIT – II **9**

Tooling Materials: Properties of Materials – Ferrous Tooling Materials – Tool steels – Cast Iron – Mild, or low-carbon Steel – Nonmetallic Tooling Materials – Nonferrous Tooling Materials – Metal cutting Tools – Single-point cutting tools – Milling cutters – Drills and Drilling – Reamer classification – Taps – Tap classification- the selection of carbide cutting tools – Determining the insert thickness for carbide tools.

UNIT – III **9**

Design of Drill Jigs and Fixtures: Introduction – Fixed Gages – Gage Tolerances – The selection of material for Gages – Indicating Gages – Automatic gages – Principles of location – Locating methods and devices – Principles of clamping – Drill jigs – Chip formation in drilling – General considerations in the design of drill jigs – Drill bushings – Methods of construction – Drill jigs and modern manufacturing. Fixtures and economics – Types of Fixtures – Vise Fixtures – Milling Fixtures – Boring Fixtures – Broaching Fixtures – Lathe Fixtures – Grinding Fixtures.

UNIT – IV **9**

Dies and Tool Design: Types of Die construction – Die-design fundamentals – Blanking and Piercing die construction – Pilots – Strippers and pressure pads- Presswork materials – Strip layout – Short-run tooling for Piercing – Bending dies – Forming dies – Drawing operations

UNIT – V **9**

Numerically Controlled Machine: The need for numerical control – A basic explanation of numeric control – Numerical control systems in use today – Fixture design for numerically controlled machine tools – Cutting tools for numerical control – Tool holding methods for numerical control – Automatic tool changers and tool positioners – Tool presetting – Introduction – General explanation of the brown and sharp machine – tooling for Automatic screw machines

Total: 45

REFERENCES:

1. Donaldson Cyrll, LeCain H. George, Goold V.C., “Tool Design”, 3rd Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2002.
2. Society of Manufacturing Engineers, “Manufacturing Engineers Handbook”, 1998.
3. Mikell P. Groover, “Fundamentals of Modern Manufacturing”, John Wiley & Sons, Singapore, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	classify the concepts and working principles of latest developments in tool design	Applying (K3)
CO2:	categorize the tooling materials	Analyzing (K4)
CO3:	summarize the design and development of drilling jigs and fixtures	Evaluating (K5)
CO4:	decide on the selection of dies for press working	Evaluating (K5)
CO5:	recommend tool holding methods for A/C machines	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3		2
CO2	3		2
CO3	3		3
CO4	3		3
CO5	3		3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18EDE08 DESIGN OF MATERIAL HANDLING EQUIPMENT

(Common to Engineering Design & CADCAM branches)

(Use of approved data book is permitted)

L	T	P	Credit
3	0	0	3

Preamble	Most of accidents occurring in industries due to improper design of material handling equipments. In order to avoid this, the design engineer should be familiar with principle and design concepts in material handling equipments.
Prerequisites	Fundamentals of Material Handling Equipment Knowledge on Machine Element and Transmission System

UNIT – I **9**

Flexible Hoisting Appliances: Type, selection and applications of material handling equipment's, choice of material handling equipment – hoisting equipment – components and theory of hoisting equipment – chain and ropes – selection of ropes, pulleys, pulley systems, sprockets and drums.

UNIT – II **9**

Load Handling Equipments and Brakes: Forged standard hooks – forged Ram shorn hooks – solid triangular eye hooks – crane grabs, electric lifting magnetic – grabbing attachments for loose materials, arresting gear – brakes: shoe, band and cone types – elements of shoe brakes – thermal calculation in shoe brakes.

UNIT – III **9**

Surface and Overhead Transportation Equipment: Hand operated trucks – powered trucks – tractors – electronically controlled tractors - hand truck on rails – industrial railroad equipment's: locomotives - winches – capstans – turntables – monorail conveyors –pipe rail systems – flat bar monorails. Rail travelling mechanism, cantilever and monorail cranes, cogwheel drive, Monocable tramways- reversible tramways.

UNIT – IV **9**

Elevating Equipment: Continuous-motion vertical conveyors – reciprocating-motion vertical conveyors – stackers – work levelers and tail gates – industrial lifts – passenger lifts – freight elevators – mast type elevators – vertical skip hoist elevators, bucket elevators: design, loading and bucket arrangements.

UNIT – V **9**

Conveying Equipment: Belt conveyors - chain conveyors – apron conveyors – escalators – flight conveyors – roller conveyors - oscillating conveyors. Design of belt conveyors, screw conveyors and pneumatic conveyors.

Total: 45

REFERENCES:

1. Rudenko N., "Materials Handling Equipment", 2nd Edition, MIR Publishers, Moscow, 1970.
2. Spivakovsky A.O. and Dyachkov V.K., "Conveying Machines", Volume I & II, MIR Publishers, Moscow, 1985.
3. Lingaiah K., "Machine Design Data Book", 2nd Edition, McGraw Hill, New York, 2003.
4. Chowdary R.B. and Tagore G.R.N., "Materials Handling Equipment", Khanna Publishers, New Delhi, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	understand the basic concepts of flexible hoisting equipment	Applying (K3)
CO2:	demonstrate the basic concepts and design the braking system for load handling equipment	Applying (K3)
CO3:	solve the problems in surface and overhead transportation equipment	Analyzing (K4)
CO4:	solve the problems and understanding the basic of elevators	Analyzing (K4)
CO5:	recognize the concepts and solve the problems of conveying equipment	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	1	3
CO2	2	1	3
CO3	3	1	3
CO4	3	1	2
CO5	3	1	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MTE01 FLUID POWER SYSTEM DESIGN

(Common to Mechatronics, Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	2	4

Preamble	This course deals with the design of a system which generate, control and transmission of power using pressurized fluids.
Prerequisites	Nil

UNIT – I **9**

Fundamentals and Power Source of Hydraulic System: Basics, Types and structure of fluid power systems – Pascal's Law and its application –Fluid properties – Losses in pipes, valves and fittings – Advantages and applications of Fluid power systems. Fluid power symbols – Hydraulic pumps: Gear, Vane and Piston pumps, Pump Performance, Characteristics and Selection - Sizing of hydraulic pumps.

UNIT – II **9**

Control Components of Hydraulic System: Direction control valves: Three-way valve, Four way valve, Check valve and shuttle valve – Actuation mechanism of DCV – Pressure control valves: Pressure relief, Pressure Reducing, Counter balance, Sequencing and Unloading Valves – Flow control valves and its types – Proportional Valves – Servo valves and its types.

UNIT – III **9**

Fundamentals of Pneumatic System: Perfect Gas laws – Compressors: piston, screw and vane compressor – Fluid conditioning Elements: Filter, Regulator and Lubricator unit, Pneumatic silencers, After coolers, Air dryers – Air control valves – Fluid power actuators: Linear and Rotary actuators – types – Cushioning mechanism in cylinders – Sizing of Actuators.

UNIT – IV **9**

Fluid Power Circuit Design: Circuit design methods: Cascade method, Step counter method and KV Map method (two / three-cylinder circuits) – Basic pneumatic circuits – Electrical components and electrical controls for Fluid power circuits – Introduction to Fluid logic devices and applications – Accumulator: Types and application circuits – Pressure intensifier circuits – PLC applications in Fluid power circuit.

UNIT – V **9**

Industrial Circuits and Maintenance: Industrial circuits: Speed control circuits – Regenerative cylinder circuits – Pump unloading circuit – Double pump circuit – Counter balance valve circuit – Hydraulic cylinder sequencing circuit – Automatic cylinder reciprocating circuit – Cylinder synchronizing circuits – Fail safe circuits - Sealing devices: Types and materials – Installation, Maintenance and trouble shooting of Fluid Power systems.

List of Experiments:

1. Design and testing of Electro-hydraulic circuit with pressure sequence valve
2. Design of hydraulic circuit for speed control of hydraulic motor and cylinder
3. Circuits with logic controls – AND valve and OR valve
4. Sequential Circuit with pneumatic control without pneumatic timers
5. Sequential Circuit with pneumatic control with pneumatic timers
6. Cylinder synchronizing circuits

7. Circuits with multiple cylinder sequence – Electrical control
8. Circuit with rod less cylinder – Electrical control
9. Proportional and Servo control of Pressure and Flow in hydraulic Circuits
10. Simulation and analysis of fluid power circuits using fluid power simulation software
Lecture: 45, Practical: 30, Total: 75

REFERENCES / MANUALS / SOFTWARES:

1.	Esposito Anthony, “Fluid Power with Applications”, 7th Edition, Pearson Education Ltd., New York, 2013.
2.	Majumdar S.R., “Pneumatic Systems – Principles and Maintenance”, 1st Edition, McGraw-Hill, New Delhi, 2017.
3.	Majumdar S.R., “Oil Hydraulic Systems – Principles and Maintenance”, 28th Edition, McGraw-Hill, New Delhi, 2017.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	identify the fluid power components, their symbols and functions	Applying (K3)
CO2:	select the required fluid power control components for a given application	Applying (K3)
CO3:	apply the pneumatic technology to design a system with low cost automation	Analyzing (K4)
CO4:	design and develop a fluid power circuit with different methodologies for an industrial environment	Creating (K6)
CO5:	design and analyze the fluid power circuit for a given application using simulation software	Creating (K6)
CO6:	identify the fluid power components and their symbols used in industry	Applying (K3), Manipulation (S2)
CO7:	design, construct and test fluid power circuits with pneumatic, electrical, PLC and logic control for low cost automation	Creating (K6), Precision (S3)
CO8:	develop and simulate fluid power circuit using simulation software for industrial application	Creating (K6), Precision (S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	2	3
CO6	3	3	3
CO7	3	3	3
CO8	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MTE04 FACTORY AUTOMATION AND CIM

(Common to Mechatronics and CAD/CAM branches)

L	T	P	Credit
3	0	0	3

Preamble	To impart fundamental knowledge about automation in the field of production and assembly lines.
Prerequisites	Nil

UNIT – I **9**

Automation: Principles and strategies - Elements of an automated system –Levels of automation – Automation in production systems – Automated manufacturing systems – Types – Reasons for automation. Material handling systems – Types – Design considerations – AGVs – Types and applications – Vehicle guidance technology - Storage systems – Performance – Methods – Automated storage systems.

UNIT – II **9**

Transfer Machines: Types, transfer machines for housing type parts, transfer systems, turning devices, pallets, mechanisms for locating and clamping housing type parts. Transfer machines for shaft production and gear production. Continuous rotary transfer lines - Layout and output. Transfer lines, Automatic Pallet Changer, Modular Fixtures.

UNIT – III **9**

Manufacturing Systems: Components of Manufacturing system - Single station manufacturing cells, Manual assembly lines - Automated production lines - automated assembly systems.

UNIT – IV **9**

Cellular Manufacturing: Group technology – Part families – Parts classification and coding – Production flow analysis – Composite part concept – Machine cell design –FMS – Types – Components – Applications and benefits - Automatic data capture - Barcode technology – Radio frequency identification.

UNIT – V **9**

CAQC and Production Planning: Benefits of CAQC - Computer Aided Inspection - Contact and Non-contact Inspection Methods - Optical and Non-optical types - Computer Aided Testing - Co-ordinate Measuring Machines (CMM). Material requirement Planning (MRP) - Structure of MRP - Inputs and Outputs of MRP - Manufacturing resource Planning (MRP II) – Enterprise Resource Planning (ERP) – Inventory control - statistical inventory control models.

Total: 45

REFERENCES:

1. Groover M.P., “Automation, Production Systems, and Computer-integrated Manufacturing”, 4th Edition, Pearson Education, 2016.
2. Groover M.P. and Zimmers E.W., “Computer Aided Design and Manufacturing”, Pearson Education, 2011.
3. Nand K. Jha, “Handbook of Flexible Manufacturing Systems”, Academic Press, Orlando, 2006.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	infer the automation principles, automated manufacturing systems and material handling systems	Understanding (K2)
CO2:	demonstrate about the transfer machines for production process	Applying (K3)
CO3:	explain the types of manufacturing systems in manufacturing plants	Understanding (K2)
CO4:	identify the coding systems for different manufacturing parts and design flexible manufacturing systems for a manufacturing industry	Applying (K3)
CO5:	illustrate computer aided quality control techniques and production planning methods in a manufacturing environment	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	1	2
CO2	3	2	3
CO3	3	1	2
CO4	2	2	2
CO5	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MTE06 METROLOGY AND COMPUTER AIDED INSPECTION

L	T	P	Credit
3	0	0	3

Preamble	To make the learner to design and fabricate inspection methods and systems incorporating electronic systems for inspection and quality control in engineering.
Prerequisites	Sensors and Signal Processing

UNIT – I **9**

Linear and Angular Measurements: Basic concept – Legal metrology- Precision- Accuracy- Types of errors – Standards of measurement- traceability – Interchange ability and selective assembly, gauge blocks, limit gauges - Gauge design. Comparators: mechanical, electronic, optical and pneumatic - Angular measurement: bevel protractor - Angle gauges - Sine bar – Autocollimator - Profile projectors.

UNIT – II **9**

Surface Finish and Form Measurement: Measurement of surface finish: terminology – Roughness – Waviness – Evaluation of surface finish - Stylus probe instrument – Talysurf – Screw thread metrology: errors in thread – Pitch error – Measurement of various elements - Two and three wire method - Best wire size - Thread gauges - Floating carriage micrometer. Measurement of gears - Terminology- Measurement of various elements of gear - Tooth thickness - Constant chord and base tangent method - Parkinson Gear Tester.

UNIT – III **9**

Laser Metrology: Characteristics of LASER sources, LASER micrometer, LASER interferometer – Constructional features - Sources of errors – Measurement of position error, straightness and angle of machine tools, LASER alignment telescope, LASER triangulation techniques. In-process and post process gauging, Automatic gauging, Tool wear measurement, Roundness measurement using LASER, Flexible inspection systems.

UNIT – IV **9**

Co-Ordinate Measuring Machines: Coordinate Metrology, types of CMM, constructional features - Structural elements - Drive systems -Support systems - Displacement transducers - Probing system – Software - Control system, temperature fundamentals and accuracy enhancement

UNIT – V **9**

Image Processing and Machine Vision System: Image processing: Image acquisition and digitization – Windowing – Segmentation - Thresholding - Edge detection techniques, interpretation - Grey scale correlation – Template matching, applications in Inspection, interfacing machine vision and robot, Reverse engineering Applications.

Total: 45

REFERENCES / MANUAL/SOFTWARES:

1. Connie Dotson, Roger Harlow and Richard Thompson, “Fundamentals of Dimensional Metrology”, 4th Edition, Thompson Asia, Singapore, 2003.
2. Jain R.K., “Engineering Metrology”, 21st Edition, Khanna Publishers, New Delhi, 2018.
3. Gupta I.C., “A Text Book of Engineering Metrology”, 7th Edition, Dhanpat Rai Publications, New Delhi, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	infer linear and angular measurements using various instruments	Understanding (K2)
CO2:	determine the surface roughness and form features measurements	Applying (K3)
CO3:	appraise laser interferometry and recent advancements in metrology	Applying (K3)
CO4:	make profile measurements using Coordinate Measuring Machine (CMM)	Applying (K3)
CO5:	apply the principle of image processing and machine vision system techniques	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	2	2
CO2	3	2	2
CO3	3	2	2
CO4	3	2	2
CO5	3	2	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MTC21 ROBOTICS ENGINEERING

(Common to Mechatronics, CADCAM & Control and Instrumentation Engineering branches)

L	T	P	Credit
3	0	2	4

Preamble	The course on Robotics Engineering is intended to provide a reasonable understanding of robotics and robot anatomy, the mathematics behind kinematics and dynamics of robot. It also involves controlling the robot motion using different control strategies.
Prerequisites	Bridge Course Mechanical and Applied Mathematics for Mechatronics

UNIT – I **9**

Introduction: History of robotics – Robot Anatomy – Robot specifications - Work space – Degree of freedom - Joint types - Types of robots – Precision of movements - End effectors – Dexterity - Robot applications.

UNIT – II **9**

Robot Kinematics: Descriptions: Position, Orientations and translation – Mapping: Changing from frame to frame – Operators: Translations, Rotation and Transformation - Homogeneous Transformation matrices - Forward and Inverse kinematics - Representation of links using Denavit - Hartenberg parameters.

UNIT – III **9**

Velocity and Static Force: Introduction - Linear and angular velocities of a rigid body - Velocity propagation – Derivation of Jacobian matrix for Serial manipulator – Singularities - Static force of serial manipulator.

UNIT – IV **9**

Robot Dynamics: Acceleration of a rigid body - Inertia of a link - Equations of motion for serial manipulators: Euler Lagrange formulation, Newton Euler formulation — Inverse dynamics of serial manipulator.

UNIT – V **9**

Robot Control: Point to point and Continuous path motions – Joint trajectory Vs Cartesian trajectory – Trajectory planning – Trajectory following - Disturbance rejection – PD and PID control – Computer torque control - Adaptive control – Feedback linearization control.

List of Experiments:

1. Study the functions of ABB IRB 1410 industrial robot- components, drive system and end effectors.
2. Virtual reality robot programming for different tasks- Painting, Pick and place and switch off intruder alarm.
3. Virtual reality robot programming for different tasks- Stacking of blocks and Machining of billets.
4. Creation of Tool Centre Point (TCP) and Work Object using ABB IRB 1410 industrial robot.
5. Pick and place operation in teach mode using ABB IRB 1410 industrial robot.
6. Machine tending operation in teach mode using ABB IRB 1410 industrial robot.
7. Robot programming exercises - Point-to-point programming.
8. Robot programming exercises - Continuous path programming.
9. Robot programming exercises – Path planning in offline mode.
10. Vision based On-line Inspection and sorting of components using ABB IRB 1410 industrial robot.

Lecture: 45, Practical:30, Total: 75

REFERENCES / MANUALS / SOFTWARES:	
1.	Groover M.P., Weiss M., Magel R.N., Odrey N.G. and Dulta A., "Industrial Robotics, Technology, Programming and Applications", 2nd Edition, McGraw-Hill Companies, 2012.
2.	Saeed B. Niku, "Introduction to Robotics: Analysis, Control, Applications", 2nd Edition, Wiley India Pvt. Ltd., 2012.
3.	Craig John J., "Introduction to Robotics: Mechanics and Control", 4th Edition, Pearson/Prentice Hall Publication, 2018.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the industrial manipulator anatomy and estimate the gripping force of robot end effector	Applying (K3)
CO2:	develop the forward and inverse kinematics for serial manipulators	Applying (K3)
CO3:	formulate Jacobian matrix for velocity and static force analysis of serial manipulators	Applying (K3)
CO4:	formulate dynamic equations for serial manipulators	Applying (K3)
CO5:	apply the scheme of trajectory planning and control for manipulator motion control	Applying (K3)
CO6:	analyze the industrial robot work cell problems	Analyzing (K4), Manipulation (S2)
CO7:	develop robot programming through online /offline mode	Creating (K6), Precision (S3)
CO8:	develop an online inspection system using machine vision	Creating (K6), Precision (S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	-	3
CO2	2	-	3
CO3	2	-	3
CO4	2	-	3
CO5	2	-	3
CO6	2	3	3
CO7	3	3	3
CO8	3	3	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCE01 COMPUTER AIDED PROCESS PLANNING

L	T	P	Credit
3	0	0	3

Preamble	The course provides a fundamental understanding of Computer Aided Process Planning. And also, it addresses the group technology and efficient process planning systems which are the most significant technologies following in major manufacturing sectors.
Prerequisites	CAD/CAM/CIM

UNIT – I **9**

Process and Production Planning: The Place of Process Planning in the Manufacturing cycle – Process Planning and Production Planning – Process Planning and Concurrent Engineering, CAPP, Group Technology.

UNIT – II **9**

Part Design Representation: Design Drafting – Dimensioning – Conventional tolerance – Geometric tolerance – CAD – input / output devices – topology – Geometric transformation – Perspective transformation – Data structure – Geometric odeling for process planning – GT coding – The optiz system – The MICLASS system.

UNIT – III **9**

Process Engineering and Process Planning: Experienced, based planning – Decision table and decision trees – Process capability analysis – Process Planning – Variant process planning – Generative approach – Forward and Backward planning, Input format.

UNIT – IV **9**

Computer Aided Process Planning Systems: Logical Design of a Process Planning Implementation considerations –manufacturing system components, production Volume, No. of production families – CAM-I, CAPP, MIPLAN, APPAS, AUTOPLAN and PRO, CPPP.

UNIT – V **9**

An Intergraded Process Planning Systems: Totally integrated process planning systems – An Overview – Modulus structure – Data Structure, operation – Report Generation, Expert process planning.

Lecture:45, Practical:30, Total: 75

REFERENCES:

1. Gideon Halevi and Roland D. Weill, "Principles of Process Planning: A logical approach", Chapman & Hall, 1995.
2. Tien-Chien Chang and Richard A.Wysk, "An Introduction to Automated Process Planning Systems", Prentice Hall, 1985.
3. Mikell P.Groover, "Automation, production System and Computer Integrated Manufacturing", 3rd Edition, Pearson, 2013.
4. Nanua Singh, "Systems Approach to Computer Integrated Design and Manufacturing", John Wiley & Sons, 1996.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	describe the process planning function in manufacturing	Understanding (K2)
CO2:	examine the part design representation for preparing GT coding	Analyzing (K4)
CO3:	demonstrate the various process planning approach	Understanding (K2)
CO4:	apply the decision making process for appropriate planning using various process planning software	Applying (K3)
CO5:	explain the integrated process planning system	Understanding (K2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2		2
CO2	2		2
CO3	2		2
CO4	2		2
CO5	2		2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18CCE02 SAFETY IN ENGINEERING INDUSTRY

(Common to CADCAM, Engineering Design & Mechatronics branches)

L	T	P	Credit
3	0	0	3

Preamble	The course deals with the study on hazards involved in performing several machining operations, safety precautions and guidelines to be followed while handling machines and industrial equipments utilizing safety devices for specified operations and types of guarding systems in machines for safe operation.
Prerequisites	Manufacturing Technology, Material Removal Processes, Thermal Engineering.

UNIT – I **9**

Safety in Metal Working Machinery and Wood Working Machines: General safety rules, principles, maintenance, Inspections of turning machines, boring machines, milling machine, planning machine and grinding machines, CNC machines, Wood working machinery, types, safety principles, electrical guards, work area, material handling, inspection, standards and codes- saws, types, hazards.

UNIT – II **9**

Principles of Machine Guarding: Guarding during maintenance, Zero Mechanical State (ZMS), Definition, Policy for ZMS – guarding of hazards - point of operation protective devices, machine guarding, types, fixed guard, interlock guard, automatic guard, trip guard, electron eye, positional control guard, fixed guard fencing- guard construction- guard opening. Selection and suitability: lathe-drilling-boring-milling-grinding-shaping-sawing-shearing-presses- forgehammer – flywheels - shafts couplings-gears-sprockets wheels and chains- pulleys and belts-authorized entry to hazardous installations-benefits of good guarding systems.

UNIT – III **9**

Safety in Welding and Gas Cutting: Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases - colour coding – flashback arrestor – leak detection - pipe line safety - storage and handling of gas cylinders.

UNIT – IV **9**

Safety in Cold Forming and Hot Working of Metals: Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes. Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills – hot bending of pipes , hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

UNIT – V **9**

Safety in Finishing, Inspection and Testing: Heat treatment operations, electro plating, paint shops, sand and shot lasting, safety in inspection and testing, dynamic balancing, hydro testing, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation. Health and welfare measures in engineering industry-pollution control in engineering industry- industrial waste disposal.

Total: 45

REFERENCES:

1.	John V. Grimaldi and Rollin H. Simonds, "Safety Management", 5^{th} Edition, All India Travelers Book Seller, New Delhi, 1991.
2.	Krishnan N.V., "Safety Management in Industry", Jaico Publishers, 1996.
3.	Jane Blunt, Nigel C. Balchin, "Health and Safety in Welding and Allied Processes", 5^{th} Edition, Woodhead Publishing Ltd., U.K., 2002.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	work safely in metal and wood working machines	Applying (K3)
CO2:	identify proper guarding for different applications	Analyzing (K4)
CO3:	work safely in welding and allied process	Analyzing (K4)
CO4:	work safely in cold and hot working metals	Applying (K3)
CO5:	handle safely testing and inspection instruments	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1			2
CO2			3
CO3			2
CO4			2
CO5			3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCE03 PRECISION ENGINEERING

L	T	P	Credit
3	0	0	3

Preamble	This course describes the materials used for precision machining and their tolerances. It also provides the precision machine elements MEMS and error control in maching.
Prerequisites	Metrology and measurements

UNIT – I **9**

Precision Engineering: Introduction - Accuracy and precision – Need – application precision machining– Tool based Micro and Ultra precision Machining grinding – Thermal effects – Materials for tools and machine elements – carbides – ceramic, CBN and diamond.

UNIT – II **9**

Tolerance and Fits: Tolerance – Zone – fits – Variation – Hole and shaft system – limits – expected Accuracy of machining processes – Selective assembly – gauges acceptance tests for machine tools.

UNIT – III **9**

Ultra Precision Machine Elements: Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers – Rolling elements – hydrodynamic and hydrostatic bearings – pneumatic bearings.

UNIT – IV **9**

MEMS: Introduction – MEMS – principle – Elements – Characteristics – Design – Application: automobile defence, aerospace etc.,

UNIT – V **9**

Error Control: Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control – errors due to locations – principle of constant location surfaces.

Total: 45

REFERENCES:

1. Nakazawa H., “Principles of Precision Engineering”, Oxford University Press, 1994.
2. Murthy R.L., “Precision Engineering in Manufacturing”, 1st Edition, New Age International Publishers, New Delhi, 1996.
3. Davidson, “Handbook of Precision Engineering”, Volume:1,12, 1st Edition, Macmillan Education, London, 1972.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	recognize know the importance of precision engineering, different cutting tool materials and its applications	Applying (K3)
CO2:	examine how to inspect the manufactured component precisely	Analyzing (K4)
CO3:	explore the ultra precision machine elements and its applications	Analyzing (K4)
CO4:	identify the fundamentals and applications of MEMS in current scenario	Applying (K3)
CO5:	evaluate the influence of thermal effects in machining	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2		2
CO2	2	1	2
CO3	3		3
CO4	3	2	3
CO5	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18CCE04 DESIGN FOR MANUFACTURE AND ASSEMBLY

(Common to CADCAM & Engineering Design branches)

L	T	P	Credit
3	0	0	3

Preamble	Products cannot be manufactured directly from the basic design by a manufacturing process, So the design is to be modified as manufacture and assembly oriented. This knowledge is necessary to get a defect free product.
Prerequisites	Machine drawing, Manufacturing Technology.

UNIT – I **9**

DFMA Guidelines and Geometric Tolerance: General design principles for manufacturability - Design for assembly - strength and mechanical factors - Geometric tolerances – Worst case method - Assembly limits – Design and Manufacturing Datum – Conversion of design datum into manufacturing datum -Tolerance stacks- Process capability.

UNIT – II **9**

Form Design: Principal materials - Selection of materials and processes - Mechanisms selection - Possible solutions - Evaluation method - Influence of materials on form design - form design of grey iron, malleable iron, steel and aluminium castings, welded members and forgings.

UNIT – III **9**

Machining Considerations: Design features to facilitate machining – Single point and multipoint cutting tools - Design for turning operation- Design for machining round holes – Design for Parts produced by milling, planning, shaping and slotting- Reduction of machined area- Simplification by separation - Simplification by amalgamation - Design for machinability - Design for economy - Design for clampability - Design for accessibility.

UNIT – IV **9**

Casting Considerations: Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes – Design rules for sand castings – Investment casting: Introduction, Design consideration of Investment casting -The die casting cycle, Determination of number of cavities and appropriate machine size in die casting- Identification of uneconomical design - Modifying the design - Computer applications in DFMA.

UNIT – V **9**

Design for the Environment: Environmental objectives – Basic DFE methods – Lifecycle assessment – AT&T's environmentally responsible product assessment - Weighted sum assessment method – Techniques to reduce environmental impact – Design to minimize material usage – Design for recyclability – Design for remanufacture – Design for energy efficiency – Design to regulations and standards.

Total: 45

REFERENCES:

1. Boothroyd G., "Product Design for Manufacture and Assembly", 3rd Edition, New York, CRC Press, London, 2013.
2. Peck Harry, "Design For Manufacture", Pitman Publications, London 1983.
3. Otto Kevien and Wood Kristin, "Product Design", 1st Edition, Pearson Publication, New Delhi, 2004.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	analyze the given component and identify the suitable geometrical tolerances for manufacturing oriented design	Analyzing (K4)
CO2:	propose design guidelines for form design of castings, welded members and forgings	Applying (K3)
CO3:	suggest suitable design modifications to facilitate machining of components	Applying (K3)
CO4:	identify uneconomical design and modify component design for sand and die castings	Analyzing (K4)
CO5:	perform the lifecycle assessment for a component to achieve eco-friendly design	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	1	3
CO2	1	1	3
CO3	1	1	3
CO4	1	1	3
CO5	2	1	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18EDE10 INSTRUMENTATION AND MEASUREMENTS

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble	Knowledge of instrument characteristics enables right choice of various measurement system components. This course helps in the design of measurement system for various applications.
Prerequisites	Basic knowledge of measurement system and its characteristics, Basic knowledge statistical mathematics.

UNIT – I **9**

Introduction to Instruments and their Representation: Typical Application of Instrument Systems, Functional Elements of a measurement System, Classification of Instruments, Standards and Calibration. Static and Dynamic characteristics of Instruments: Introduction, Accuracy, Precision, Resolution, Threshold, Sensitivity, Linearity, Hysteresis, Dead Band, Backlash, Drift, Formulation of Differential Equations for Dynamic Performance- Zero Order, First Order and Second order systems, Response of First and Second Order Systems to Step, Ramp, Impulse and Harmonic Functions, Problems including the characteristics study, Error Analysis.

UNIT – II **9**

Transducer Elements: Analog and Digital Transducers, Variable Capacitance, Piezo-Electric Transducer and Associated Circuits, Unbonded and Bonded Resistance Strain Gages. Strain Gage Bridge circuits, Digital Transducers, Frequency Domain Transducer, Vibrating String Transducer, Binary codes, Digital Encoders. Modern Transducer

UNIT – III **9**

Intermediate, Indicating and Recording Elements: Amplifiers, Mechanical, Hydraulic, Pneumatic, Optical, Electrical Amplifying elements, Compensators, Differentiating and Integrating Elements, Filters, Classification of Filters, A-D and D-A Converters, Digital Voltmeters (DVMs), Cathode Ray Oscillo scopes (CROs), Galvanometric Recorders, Magnetic Tape recorders, Data Acquisition Systems, Data Display and Storage.Modern trends in intermediate elements

UNIT – IV **9**

Motion, Force and Torque Measurement: Relative motion Measuring Devices, Electromechanical, Optical, Photo Electric, Moire-Fringe, Pneumatic, Absolute Motion Devices, Seismic Devices, Spring Mass and Force Balance Type, Hydraulic Load Cell, Pneumatic Load Cell, Elastic Force Devices, Separation of Force Components, Electro Mechanical Methods, Strain Gage, Torque Transducer, and Torque Meters. Methods used in modern research

UNIT – V **9**

Pressure, Flow and Temperature Measurement: Pressure Measurement: Moderate Pressure Measurement, Monometers, Elastic Transducer, Dynamic Effects of Connecting Tubing, High Pressure Transducer, Low Pressure Measurement, Calibration and Testing Flow Measurement: Quantity and rate meters, Flow visualization and its techniques, Modern Trends. Measurement of Temperature: Non Electrical Methods – Solid Rod Thermometer, Bimetallic Thermometer, Pressure Thermometer, Electrical Methods – Electrical Resistance Thermometers-RTDs, Semiconductor Resistance Sensors (Thermistors), Thermo– Electric Sensors, Thermocouple Materials and circuitry, Modern Trends

Total: 45

REFERENCES:

1. Ernest O. Doebelin, “Measurement System: Application and Design”, 5th Edition, McGraw Hill, 2003.
2. Alan S. Morris and Reza Langari, “Measurement and Instrumentation – Theory and Application”, Elsevier, 2015.
3. Nakra B.C. and Chaudhary K.K., “Instrumentation, Measurement and Analysis”, Tata McGraw Hill, 2003.
4. Kumar D.S., “Mechanical Measurements and Control Engineering”, Metropoliton Book Company, 1979.
5. Tayal A.K., “Instrumentation, Mechanical Measurements and Controls”, Galgotia Publisher, Reprint 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	carryout characteristic analysis of instrument	Analyzing (K4)
CO2:	select transducers at different stages of a measurement system and relate them to manipulation and presentation devices	Applying (K3)
CO3:	identify and relate manipulating and presentation elements	Applying (K3)
CO4:	apply concepts of motion, force and torque measurement in research/modern application	Applying (K3)
CO5:	plan and use pressure, flow and temperature measuring instruments in day to day and modern application	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	1	2
CO2	2	1	2
CO3	2	1	2
CO4	3	1	2
CO5	3	1	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18EDE12 PRODUCTIVITY MANAGEMENT AND REENGINEERING

(Common to Engineering Design & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble	This course provides advanced topics for productivity concepts & measurements, steps & procedures of reengineering procedures and improvement models.
Prerequisites	Fundamentals of production and process, Knowledge in basics of mathematics, Fundamentals steps of software, Essentials knowledge of various production resources

UNIT – I **9**

Introduction of Productivity Concepts: Definitions and various factors for productivity – problems in productivity and production –comparison of productivity measures- Productivity concepts – Macro and Micro factors of productivity, Productivity benefit model-case study- productivity cycle.

UNIT – II **9**

Productivity Measurement: Productivity measurement at International, National and Organizational level-External Environment Economic utility model with productivity index, Total productivity models- problems -Strategies for productivity improvement.

UNIT – III **9**

Productivity Management and Organizational Transformation: Productivity management in manufacturing and service sector-case study -Productivity evaluation models, Productivity improvement models and techniques – laboratory -case study. Principles of organizational transformation and re-engineering, fundamentals of process reengineering, preparing the work force for transformation and reengineering, methodology and guidelines.

UNIT – IV **9**

Productivity Models: PMI models, Edosomwan model, Moen and Nolan strategy for process improvement, LMICIP model, NPRDC model –Case studies and applications -DSMCQ and PMP model-case study.

UNIT – V **9**

Re-Engineering Process Improvement Models, Re-Engineering Tools and Implementation: Analytical and process tools and techniques process tools and packages - Information and communication technology - Enabling role of IT.RE-opportunities, process redesign - cases. Software methods in BPR tools and techniques matrix-case study based on information resources - specification of BP, case study - Order, processing, user interfaces, maintainability and reusability-case study from few information resources-application models.

Total: 45

REFERENCES:

1. Sumanth D.J., "Productivity Engineering and Management", Tata McGraw-Hill, New Delhi, 2008.
2. Edosomwan J.A., "Organizational Transformation and Process Re-engineering", CRC Press, 1995.
3. Rastogi P.N., "Re-Engineering and Re-inventing the Enterprise", Wheeler Publishing, New Delhi, 2003.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	recollect macro and micro factors affecting productivity	Understanding (K2)
CO2:	categorize the productivity measurement models	Evaluating (K5)
CO3:	prepare workforce by incorporating transformation and reengineering techniques	Evaluating (K5)
CO4:	dramatize productivity models for applications and cases	Applying (K3)
CO5:	summarize the reengineering process tools and models	Evaluating (K5)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	2	3
CO2	3	2	3
CO3	3	2	3
CO4	3	2	3
CO5	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18MTT13 SENSORS AND INSTRUMENTATION

(Common to Mechatronics, Engineering Design and CAD/CAM Branches)

L	T	P	Credit
3	0	0	3

Preamble	To impart basic knowledge about sensors used to measure various physical quantities like resistance, pressure, flow, level, humidity and so on and convert them into electronic signals (digital or analog) that can be easily read by the user or any other instrument.
Prerequisites	Physics

UNIT – I **9**

Introduction to Measurement: Units and Standards - Instrument classification - Calibration techniques - Characteristics of Instruments - Static and dynamic - Classification of errors - Error analysis - Statistical methods - Uncertainty.

UNIT – II **9**

Non-electrical Transducers: Classification of transducers - Temperature Measurement: Filled system thermometer - Bimetallic thermometer - Pressure Transducers: Elastic transducers - Bourdon gauge - Bellows - Diaphragm. Vacuum: McLeod gauge, thermal conductivity gauge - Ionization gauge.

UNIT – III **9**

Electrical Transducers: Turbine flow meter, Electromagnetic flow meter - Hot wire anemometer - Ultrasonic Meter - Resistive transducers - Potentiometer - RTD - Thermistor - Thermocouple - Radiation Pyrometer.

UNIT – IV **9**

Force, Displacement, Magnetic and Digital Sensors: Strain gauges - Force measurement - Inductive transducer - LVDT - RVDT - Capacitive transducer - Piezo electric transducer – Magnetic Sensor- Types – Magneto resistive – Hall effect – Current sensor - Digital displacement transducers. Digital transducers: Encoders – Fiber optic sensors – Film sensors - Introduction to MEMS and Nano sensors.

UNIT – V **9**

Signal Conditioning and Data Acquisition: Need for Signal Conditioning - Amplification - Filtering - Sample and Holding - Data logging and Acquisition - Distributed Data Acquisition and control systems - Interface system and standards.

Total: 45

REFERENCES:

1. Doebelin E.O., “Measurement Systems – Applications and Design”, 6th Edition, Tata McGraw Hill, New Delhi, 2017.
2. Sawhney A.K., “A course in Electrical and Electronic Measurement and Instrumentation”, Dhanpat Rai and Co. Pvt. Ltd., New Delhi, 2017.
3. Beckwith, Marangoni and Lienhard, “Mechanical Measurements”, 6th Edition, Addison–Wesley, New York, 2009.
4. Roy Choudry D., and Sheil Jain, “Linear Integrated Circuits”, New Age International Pvt. Ltd., New Delhi, 2014.
5. Patranabis D., “Sensor and Actuators”, Prentice Hall of India, 2005.
6. Manabendra Bhuyan, “Intelligent Instrumentation: Principles and Applications”, CRC Press, Newyork, 2011.
7. Barney G.C.V., “Intelligent Instrumentation”, Prentice Hall of India Pvt. Ltd., New Delhi, 1988.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	demonstrate the basic concepts of measurement system and error analysis	Understanding (K2)
CO2:	categorize the different type of non-electrical transducers based on the applications	Applying (K3)
CO3:	correlate the different type of electrical transducers for various applications	Applying (K3)
CO4:	infer the role of sensors in evolving technologies	Understanding (K2)
CO5:	analyze the need for signal conditioning, filters and acquiring data in real time systems	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	1	2	3
CO2	3	2	1
CO3	2	3	3
CO4	3	2	1
CO5	1	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom’s Taxonomy

18MTE12 AUTONOMOUS MOBILE ROBOTICS

(Common to Mechatronics & CAD CAM branches)

L	T	P	Credit
3	0	2	4

Preamble: The course on Autonomous Mobile Robots provides the fundamentals of mobile robotics and the basic principles of locomotion, kinematics, sensing, perception and cognition which are the key elements to develop the autonomous mobile robots.

Prerequisites: Robotics Engineering

UNIT – I **9**

Mobile Robot Kinematics: Introduction **-** Kinematic models and constraints – Manoeuvrability – Workspace – Motion control

UNIT – II **9**

Locomotion: Introduction – Key issues for locomotion – Legged mobile robots – Wheeled mobile robots – Aerial mobile robots

UNIT – III **9**

Perception: Introduction - Sensors for mobile robots – Fundamentals of computer vision and image processing – Feature extraction based on range data - Image feature extraction – Place recognition.

UNIT – IV **9**

Localization: Introduction – Challenges of localization – Belief representation – Map representation – Probabilistic Map-Based localization – Autonomous map building.

UNIT – V **9**

Planning and Navigation: Introduction – Competence for Navigation: Planning and Reacting – Path planning – Obstacle avoidance – Navigation architectures.

List of Experiments:

1. Study of Fire Bird – V robot and its accessories.
2. Development of embedded programming for Buzzer interfacing using Fire Bird – V robot.
3. Development of embedded programming for LCD interfacing using Fire Bird – V robot.
4. Development of embedded programming for motion control using Fire Bird – V robot.
5. Development of embedded programming for position control using Fire Bird – V robot.
6. Development of embedded programming for velocity control using Fire Bird – V robot.
7. Development of embedded programming for ADC interfacing using Fire Bird – V robot.
8. Development of embedded programming for path planning using Fire Bird – V robot.
9. Development of embedded programming for obstacle avoidance using Fire Bird – V robot.
10. Development of embedded programming for wireless motion control of Fire Bird V robot using ZigBee Communication.

Lecture: 45, Practical: 15, Total: 60

REFERENCES:

1. Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 2nd Edition, MIT Press, Cambridge, 2011.
2. Farbed Fahimi, "Autonomous Robots – Modeling, Path Planning and Control", Springer, 2009.
3. Alonzo Kelly, "Mobile Robotics: Mathematics, Models and Methods", Cambridge University Press, 2013.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	develop the kinematic model of mobile robots	Evaluating (K5)
CO2:	interpret the different concepts of locomotion	Applying (K3)
CO3:	select the sensory devices for environmental perception	Applying (K3)
CO4:	identify the techniques for localization	Applying (K3)
CO5:	apply the concepts of planning and navigation	Applying (K3)
CO6:	develop embedded programming for motion control	Applying (K3), Manipulation (S2)
CO7:	develop embedded programming for planning and navigation	Creating (K6), Precision (S3)
CO8:	develop embedded programming for wireless control	Creating (K6), Precision (S3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2		3
CO2	2		3
CO3	2		3
CO4	2		3
CO5	2		3
CO6	3	2	3
CO7	3	2	3
CO8	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18MTE13 MEMS DESIGN

(Common to Mechatronics, CADCAM, Engineering Design, VLSI Design, Applied Electronics, Power Electronics and Drives & Control and Instrumentation Engineering branches)

L	T	P	Credit
3	0	0	3

Preamble: This course equips the students to understand the concepts of Micro mechatronics and apply the knowledge of micro fabrication techniques for various applications.

Prerequisites: Sensors and Instrumentation and Bridge course mechanical

UNIT – I **9**

Materials for MEMS and Scaling Laws: Overview - Microsystems and microelectronics - Working principle of Microsystems - Si as a substrate material - Mechanical properties - Silicon compounds - Silicon piezo resistors - Gallium arsenide - Quartz-piezoelectric crystals - Polymer - Scaling laws in Miniaturization.

UNIT – II **9**

Micro Sensors, Micro Actuators: Micro sensors - Micro actuation techniques - Micro actuators – Micromotors – Microvalves – Micro grippers – Micro accelerometer: introduction, types, actuating principles, design rules, modeling and simulation, verification and testing, applications.

UNIT – III **9**

Mechanics for Microsystem Design: Static bending of thin plates - Mechanical vibration - Thermo mechanics - Thermal stresses - Fracture mechanics - Stress intensity factors, fracture toughness and interfacial fracture mechanics-Thin film Mechanics-Overview of Finite Element Stress Analysis.

UNIT – IV **9**

Fabrication Process and Micromachining: Photolithography - Ion implantation - Diffusion – Oxidation – CVD - Physical vapor deposition - Deposition by epitaxy - Etching process- Bulk Micro manufacturing - Surface micro machining – LIGA –SLIGA.

UNIT – V **9**

Micro System Design, Packaging and Applications: Design considerations - Process design - Mechanical design – Mechanical Design using Finite Element Method-Micro system packaging – Die level - Device level - System level – Packaging techniques - Die preparation - Surface bonding - Wire bonding – Sealing - Applications of micro system in Automotive industry: Bio medical, Aerospace and Telecommunications – CAD tools to design a MEMS device.

Total: 45

REFERENCES:

1. Tai-Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata McGraw-Hill, New Delhi, 2008.
2. Mohamed Gad-el-Hak, "The MEMS Handbook", CRC Press, 2009.
3. Bao M.H., "Micromechanical Transducers: Pressure sensors, accelrometers, and gyroscopes", Elsevier, New York, 2000.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	interpret the concepts of MEMS materials and scaling laws	Remembering (K1)
CO2:	explain the principles of micro sensors and actuators	Understanding (K2)
CO3:	apply the mechanics for micro system design	Applying (K3)
CO4:	design and fabrication of microsystem	Applying (K3)
CO5:	design of microsystem packaging and application	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	2	2
CO2	2	2	3
CO3	2	2	3
CO4	3	2	3
CO5	3	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18MTE14 MACHINE TOOL CONTROL AND CONDITION MONITORING

(Common to Mechatronics & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble: To impart the knowledge in machine tool control and condition monitoring in a mechatronics perspective.

Prerequisites: Nil

UNIT – I **9**

Overview of Automatic Control in Machine Tools: Open loop and closed loop system in machine tools - process model formulation - transfer function. Control actions - block diagram representation of mechanical pneumatic and electrical systems. Process computer: Peripherals, Data Logger, Direct digital control - Supervisory computer control.

UNIT – II **9**

Adaptive Control and PLC: Adaptive control: ACC, ACO, Real time parameter estimation, Applications of adaptive control for turning, milling, grinding and EDM. Programmable logic controller: Functions, Applications in machine tools.

UNIT – III **9**

Introduction to Condition Monitoring: Condition Monitoring: Cost comparison with and without CM. On-load testing and offload testing – Methods and instruments for CM: Temperature sensitive tapes, Pistol thermometers. Wear-debris analysis.

UNIT – IV **9**

Vibration, Acoustic Emission and Sound Monitoring: Primary and Secondary signals: Online and Off - line monitoring. Fundamentals of Vibration: Sound, Acoustic Emission. Machine Tool Condition Monitoring through Vibration, Sound, Acoustic Emission - Case Studies.

UNIT – V **9**

Condition Monitoring through other techniques: Visual and temperature monitoring - Leakage monitoring - Lubricant monitoring - condition monitoring of Lube oil and Hydraulic systems - Thickness monitoring - Image processing techniques in condition monitoring.

Total: 45

REFERENCES:

1. Sushil Kumar Srivastava, “Industrial Maintenance Management” S. Chand & Company Ltd., New Delhi, 2016.
2. Mishra R.C., Pathak K., “Maintenance Engineering and Management”, Prentice Hall of India Pvt. Ltd., 2016.
3. Robert Bond Randall, “Vibration-Based Condition Monitoring – Industrial, Aerospace and Automotive applications”, John Wiley & Sons Ltd., 2014.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	summarize the concepts of automatic control in machine tools	Understanding (K2)
CO2:	choose the type of adaptive control and PLC for machining operations	Applying (K3)
CO3:	explain the concepts of condition monitoring techniques	Understanding (K2)
CO4:	select the condition monitoring technique for the machine tool among vibration, acoustic emission and sound analysis	Analyzing (K4)
CO5:	select appropriate condition monitoring technique for machine tool control applications	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	2	2
CO3	3	2	3
CO4	3	2	3
CO5	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18MTE16 ADDITIVE MANUFACTURING

(Common to Mechatronics & CADCAM branches)

L	T	P	Credit
3	0	0	3

Preamble: This course provides scientific as well as technological aspects of various additive, subtractive and formative rapid manufacturing processes. Variety of applications also will be covered ranging from rapid prototyping, rapid manufacturing to mass customization.

Prerequisites: Nil

UNIT – I **9**

Introduction to RP systems: Evolution, fundamental fabrication processes, CAD for RPT, product design and rapid product development - Need for time compression in product development - Conceptual design - Detail design, Prototype fundamentals - Fundamentals of RP systems – RP process chain - 3D modelling - 3D solid modeling software and their role in RPT - Data format - STL files- Creation of STL file - History of RP systems - Classification of RP systems - Benefits of RPT.

UNIT – II **9**

Liquid based RP systems: Stereo Lithography Apparatus (SLA): Principle, Photo polymers, Post processes, Process parameters, Machine details, Advantages. Solid Ground Curing (SGC): Principle, Process parameters, Process details, Machine details, Limitations. Solid Object Ultraviolet Laser Printer (SOUP): Principle, Process parameters, Process details, Machine details, Applications.

UNIT – III **9**

Solid based RP systems: Fusion Deposition Modeling (FDM): Principle, Raw materials, BASS, Water soluble support system, Process parameters, Machine details, Advantages and limitations. Laminated Object Manufacturing (LOM): Principle, Process parameters, Process details, Advantages and limitations. Solid Deposition Manufacturing (SDM): Principle, Process parameters, Process details, Machine details, Applications.

UNIT – IV **9**

Powder based RP systems: Selective Laser Sintering (SLS): Principle, Process parameters, Process details, Machine details, Advantages and applications. 3-Dimensional Printers (3DP): Principle, Process parameters, Process details, Machine details, Advantages and limitations. Laser Engineered Net Shaping (LENS): Principle, Process details, Advantages and applications, Concept Modelers.

UNIT – V **9**

Rapid Tooling and Applications of RP: Direct Rapid Tooling: Direct AIM, Quick cast process, Copper polyamide, Rapid Tool, DMLS, ProMetal, Sand casting tooling. Indirect Rapid Tooling: Silicone rubber tooling, Aluminum filled epoxy tooling, Spray metal tooling, soft tooling vs hard tooling. Applications of RP in product design: automotive industry, medical field – Conversion of CT/MRI scan data - Customized implant - Case studies -reverse engineering - Surface Generation from points on cloud - Growth of RP industry.

Total: 45

REFERENCES:

1. Chua C. K., Leong K.F. and Lim C.S., “Rapid Prototyping: Principles and Applications”, World Scientific, New Jersey, 2010.
2. Pham D.T. and Dimov S.S., “Rapid manufacturing”, Springer-Verlag, London, 2011.
3. Amitabha Ghosh, “Rapid manufacturing a brief introduction”, Affiliated East West Press, New Delhi, 2016.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	apply the concepts of rapid prototyping in product design and development	Applying (K3)
CO2:	select the suitable liquid based rapid prototyping system for a specific application	Applying (K3)
CO3:	select the suitable solid based rapid prototyping system for a specific application	Applying (K3)
CO4:	select the suitable powder based rapid prototyping system for a specific application	Applying (K3)
CO5:	relate the various tooling systems and reverse engineering concepts for rapid manufacturing applications	Analyzing (K4)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	3	1	2
CO2	3	1	2
CO3	3	1	2
CO4	3	1	2
CO5	3	1	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT – Bloom's Taxonomy

18CCE05 PRODUCT DATA MANAGEMENT
(Common to CAD/CAM and Engineering Design branches)

L	T	P	Credit
3	0	0	3

Preamble	This course will help the students to capture and maintain detailed information on products through its development and the whole lifecycle of the product. It have the advantages of Track and manage all changes to product related data, spend less time organizing and tracking design data and improve productivity through reuse of product design data.
Prerequisites	Knowledge in bill of materials, Knowledge on product life cycle.

UNIT – I **9**

Description of PDM: Definition, Basic functionality, Typology of PDM functions. Information architecture: Document management, creation and viewing of documents, creating parts, versions and version control of parts and documents. System architecture: Client server system in PDM. Trends in PDM, Collaborative Product Development, Case studies.

UNIT – II **9**

Configuration Management: Base lines, meta data, Configuration management: CM function, CM ladder, interchangeability. Structuring the Bill of Material, product structure, Engineering structure, Manufacturing Structure. Case studies

UNIT – III **9**

Change Management: Change issue, change requests: production problem, origination of change, change request, request process, concept of Engineering change order. Change Cost: Costing a change, Design and Development Cost, Manufacturing and Field Costs, Materials and Parts Costs, Cost policy, Charge Back of Costs. Case studies.

UNIT – IV **9**

Change Control and Work Flow: Types of change, Class of change, software changes, Revision drafting, change impacts, customer review and approval. Projects and Roles: life cycle of a product, life cycle management. Work flows - creation of work flow templates, life cycle, work flow integration. Case studies.

UNIT – V **9**

Configurators and Variants: Configurators: Product configurator, sales configurator, comparison between product configurator and sales configuration, Types of configurator solutions, Product configurator engine. Variant configuration. Case studies.

Total: 45

REFERENCES:

1. IvicaCrnkovic, Ulf Asklund, AnnitaPersson Dahlqvist, “Implementing and Integrating Product Data Management and Software Configuration Management”, Artech House, USA, 2003.
2. Frank B. Watts, “Engineering Documentation Control Handbook – Configuration Management”, 4th Edition, William Andrew, Norwich, NY USA, 2011.
3. AnttiSaaksvuori, AnselmiImmonen, “Product Lifecycle Management”, 3rd Edition, Springer, New York, 2008.

COURSE OUTCOMES: On completion of the course, the students will be able to		BT Mapped (Highest Level)
CO1:	summarize the concept of PDM	Understanding (K2)
CO2:	develop a configuration management in a PLM environment	Applying (K3)
CO3:	classify the various workflows and roles in a project	Analyzing (K4)
CO4:	identify the product life cycle in change management and its issues	Applying (K3)
CO5:	make use of different configurators for product selection	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	1	2	1
CO2	3	3	3
CO3	3	3	3
CO4	2	3	2
CO5	2	1	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCE06 MODELING AND ANALYSIS OF MANUFACTURING SYSTEMS

(Common to CAD/CAM, Engineering Design & Mechatronics Branches)

L	T	P	Credit
3	0	0	3

Preamble	This course provides the knowledge of modeling analysis of manufacturing systems which ensures a very good performance.
Prerequisites	Industrial Engineering

UNIT – I **9**

Manufacturing Systems and Models: Types and principles of manufacturing systems, types and uses of manufacturing models, physical models, mathematical models, model uses, model building.

UNIT – II **9**

Material Flow Systems: Assembly lines-Reliable serial systems, approaches to line balancing, sequencing mixed models. Transfer lines and general serial systems-paced lines without buffers, unpaced lines. Shop scheduling with many products. Flexible manufacturing systems-system components, planning and control. Group technology-assigning machines to groups, assigning parts to machines. Facility layout-Quadratic assignments problem approach, graphic theoretic approach.

UNIT – III **9**

Supporting Components: Machine setup and operation sequencing-integrated assignment and sequencing. Material handling systems-conveyor analysis, AGV systems. Warehousing-storage and retrieval systems, order picking.

UNIT – IV **9**

Generic Modeling Approaches: Analytical queuing models, a single workstation, open networks, closed networks. Empirical simulation models-event models, process models, simulation system, example manufacturing system

UNIT – V **9**

Synchronization Manufacturing and Petri Nets: Synchronization Vs Optimization, defining the structure, identifying the constraint, exploitation, buffer management. Basic definitions-dynamics of Petri nets, transformation methods, event graphs, modeling of manufacturing systems

Total: 45

REFERENCES:

1. Ronald G. Askin, and Charles R. Standridge, “Modeling and Analysis of Manufacturing Systems”, John Wiley & Sons, New York, 1993.
2. Mengchu Zhou, “Modeling, Simulation, and Control of Flexible Manufacturing Systems: A Petri Net Approach”, World Scientific Publishing Co. Pte. Ltd., 2000.
3. Jean Marie Proth and XiaolanXie, “Petri Nets:A Tool for Design and Management of Manufacturing Systems”, John Wiley & Sons, New York, 1996.
4. Brandimarte P. and Villa A., “Modeling Manufacturing Systems”, Springer Verlag, Berlin, 1999.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	select the appropriate type of manufacturing system and model	Analyzing (K4)
CO2:	know about the assembly line transfer line and FMS	Understanding (K2)
CO3:	usage of various materials handling systems	Applying (K3)
CO4:	know the generic modeling systems	Understanding (K2)
CO5:	use the-theory of constraints for manufacturing a component	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1			2
CO2	3		
CO3	2		2
CO4	2		3
CO5			2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCE07 METROLOGY AND NON DESTRUCTIVE TESTING

L	T	P	Credit
3	0	0	3

Preamble	Knowledge of metrology and SQC helps in implementing quality improvement on continues basis. Application of NDT techniques helps in easy identification of defects.
Prerequisites	Basics of Metrology

UNIT – I **9**

Measuring Machines: Tool Maker's microscope - Co-ordinate measuring machines - Universal measuring machine - Laser viewers for production profile checks - Image shearing microscope – Use of computers - Machine vision technology - Microprocessors in metrology.

UNIT – II **9**

Statistical Quality Control: Data presentation - Statistical measures and tools - Process capability - Confidence and tolerance limits - Control charts for variables and for fraction defectives - Theory of probability - Sampling - ABC standard - Reliability and life testing.

UNIT – III **9**

Liquid Penetrant and Magnetic Particle Tests: Visual test aids Characteristics of liquid penetrants - different washable systems - Developers - applications - Methods of production of magnetic fields - Principles of operation of magnetic particle test - Applications - Advantages and limitations, standards and calibration.

UNIT – IV **9**

Radio Graphy: Sources of ray-x-ray production - properties of d and x rays - film characteristics - exposure charts - contrasts - operational characteristics of x ray equipment – applications, standards and calibration, study of films used and its characteristics

UNIT – V **9**

Ultrasonic and Acoustic Emission Techniques: Production of ultrasonic waves - different types of waves - general characteristics of waves - pulse echo method - A, B, C scans - Principles of acoustic emission techniques - Advantages and limitations - Instrumentation – applications, standards and calibration, advanced methods in measurements-PAUT and TOFD.

Total: 45

REFERENCES:

1. Barry Hull and Vernon John, "Non Destructive Testing", 1st Edition, MacMillan, 1988.
2. American Society for Metals, "Metals Hand Book", Vol.II, 1976.
3. Jain R.K., "Engineering Metrology", Khanna Publishers, 1997.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	explain methods and principles used in measurement	Understanding (K2)
CO2:	apply SQC techniques and tools in quality control	Applying (K3)
CO3:	make use of liquid penetrant and magnetic particle tests in inspection	Applying (K3)
CO4:	choose radiography instruments for different application	Applying (K3)
CO5:	experiment with ultrasonic and acoustic emission techniques	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	1	2	2
CO2	2	1	2
CO3	2	1	2
CO4	2	1	2
CO5	3	1	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCE08 RELIABILITY ENGINEERING
(Common to CAD/CAM & Engineering Design branches)

L	T	P	Credit
3	0	0	3

Preamble	This course provides the advanced topics of reliability measurements. Also it provides monitoring and improvement techniques for reliability engineering.
Prerequisites	Total Quality Management, Process planning and cost estimation.

UNIT – I **9**

Reliability Concept: Reliability definition – Quality and Reliability– Reliability mathematics – Reliability functions – Hazard rate – Measures of Reliability – Design life –A priori and posterior probabilities – Mortality of a component –Bath tub curve – Useful life.

UNIT – II **9**

Failure Data Analysis: Data collection –Empirical methods: Ungrouped/Grouped, Complete/Censored data – Time to failure distributions: Exponential, Weibull – Hazard plotting – Goodness of fit tests-problems and case study.

UNIT – III **9**

Reliability Assessment: Different configurations – Redundancy – m/n system – Complex systems: RBD – Baye‘s method – Cut and tie sets – Fault Tree Analysis – Standby system **-**problems and case study.

UNIT – IV **9**

Reliability Monitoring: Life testing methods: Failure terminated – Time terminated – Sequential Testing – Reliability growth monitoring – Reliability allocation – Software reliability- problems and case study.

UNIT – V **9**

Reliability Improvement: Analysis of downtime – Repair time distribution – System MTTR – Maintainability prediction – Measures of maintainability – System Availability – Replacement theory-problems and case study.

Total: 45

REFERENCES:

1. Charles E. Ebeling, “An Introduction to Reliability and Maintainability Engineering”, 3rd Edition, Wave land Press Inc, 2019.
2. Roy Billington and Ronald N. Allan, “Reliability Evaluation of Engineering Systems”,2nd Edition, Springer, 1992.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	discuss the fundamentals of reliability measures	Understanding (K2)
CO2:	summarize reliability engineering through product life cycle	Evaluating (K5)
CO3:	analyze the reliability configuration using assessment techniques	Analyzing (K4)
CO4:	apply and test product using reliability monitoring methods for given case	Evaluating (K5)
CO5:	examine system downtime and maintainability measures for given case	Applying (K3)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	2	3
CO2	2	2	3
CO3	2	2	3
CO4	2	2	3
CO5	2	2	3

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy

18CCE09 INTEGRATED PROCESS AND PRODUCT DEVELOPMENT

L	T	P	Credit
3	0	0	3

Preamble	This course will provide a management technique which integrates all necessary activities through the use of multidisciplinary teams to optimize the design, manufacturing and supportability processes.
Prerequisites	Basic knowledge in new product development, Knowledge in bill of materials, Knowledge in customer survey and product structure

UNIT – I **9**

Introduction to Product Development: Characteristics of Successful Product Development-Who Designs and Develops Products-Duration and Costs of Product Development- Challenges of Product Development - Development Processes and Organizations-A Generic Development Process-Concept Development: The Front-End Process Adapting the Genetic Product Development Process- Product Development Process Flows-The AMF Development Process-Product Development Organizations-The AMF Organization

UNIT – II **9**

Product Planning: Product Planning Process- Identify Opportunities- Evaluating and Prioritizing Projects-Allocating Resources and Timing- Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs- Raw Data from Customers- Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs-Reflecting on the Results and the Process

UNIT – III **9**

Product Specifications: What Are Specifications -When Are Specifications Established-Establishing Target Specifications-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation-Clarify the Problem- Search Externally-Search Internally-Explore Systematically- Reflect on the Results and the Process.

UNIT – IV **9**

Concept Selection: Concept Selection- Overview of Methodology-Concept Screening-Concept Testing-Define the Purpose of the Concept Test- Choose a Survey Population- Choose a Survey Format-Communicate the Concept- Measure Customer Response-Interpret the Results- Reflect on the Results and the Process

UNIT – V **9**

Product Architecture: Product Architecture-Implications of the Architecture-Establishing the Architecture-Delayed Differentiation-Platform Planning-Related System-Level Design Issues-Case studies.

Total: 45

REFERENCES:

1. Ulrich Karl T. and Eppinger Steven D., "Product Design and Development", 6th Edition, McGraw- Hill, New York, 2016.
2. Otto, Kevien and Wood, Kristin, "Product Design", 4th Edition, Pearson Publications, New Delhi, 2009.
3. Rosenthal, Stephen, "Effective Product Design and Development", Irwin Professional Publication, 1992.
4. Pugh Stuart, "Total Design: Integrated Methods for successful Product Engineering", Addison Wesley Publishing, New York, 1991.

COURSE OUTCOMES: On completion of the course, the students will be able to		**BT Mapped (Highest Level)**
CO1:	demonstrate product development process and organization	Understanding (K2)
CO2:	develop a product planning process for new products	Applying (K3)
CO3:	examine specifications of a product and generate concept for new products	Analyzing (K4)
CO4:	select suitable product concept so that, the product will compete in a market	Applying (K3)
CO5:	develop product architecture, to enable easy manufacturing of product	Applying (K3)
CO6:	demonstrate product development process and organization	Understanding (K2)

Mapping of COs with POs

COs/POs	PO1	PO2	PO3
CO1	2	3	2
CO2	3	3	2
CO3	3	2	3
CO4	2	2	3
CO5	3	2	3
CO6	2	3	2

1 – Slight, 2 – Moderate, 3 – Substantial, BT - Bloom's Taxonomy