NANDHA ENGINEERING COLLEGE

(An Autonomous Institution affiliated to Anna University Chennai and approved by AICTE, New Delhi)
Erode-638 052, Tamilnadu, India, Phone: 04294 – 225585

Curriculum and Syllabi

for

M.E – Engineering Design [R22]

[CHOICE BASED CREDIT SYSTEM]

(This Curriculum and Syllabi are applicable to Students admitted from the academic year (2022-23) onwards)

AUGUST 2022

INSTITUTE VISION AND MISSION	
VISION	• To be an Institute of excellence providing quality Engineering, Technology and Management education to meet the ever changing needs of the society.
MISSION	• To provide quality education to produce ethical and competent professionals with social Responsibility • To excel in the thrust areas of Engineering, Technology and Entrepreneurship by solving real- world problems. • To create a learner centric environment and improve continually to meet the changing global needs.

M.E –ENGINEERING DESIGN	
VISION	• To be recognised as a centre of excellence in the field of Mechanical Engineering and to produce competent engineers with multi-disciplinary exposure to meet the changing needs of the society.
MISSION	• To enrich technical knowledge and skills by imparting quality education with ethics and social responsibility. • To empower the students in the thrust areas of Mechanical, Allied Engineering and Entrepreneurship in the continually changing global market. • To provide a conducive learning environment for improving continually to cater the needs of the society.
PROGRAMME EDUCATIONAL OBJECTIVES (PEO)	**The graduates of Mechanical Engineering will be** **PEO1: Core Competency:** Graduates will have technical knowledge, skills and analytical ability to design, develop and test Mechanical or allied Engineering systems using modern tools. **PEO2: Research, Innovation and Entrepreneurship:** Graduates will have ability to take up real life and/or research related problems and to provide innovative solutions through comprehensive analysis and designing for a successful career in research or entrepreneurship. **PEO3: Ethics, Human values and Life-long learning:** The graduates will have ability to develop lifelong learning attitudes, ethics and values for a successful professional career.
PROGRAMME SPECIFIC OUTCOMES (PSO)	**The students of Mechanical Engineering will be able to** **PSO1:** An ability to identify, comprehend, formulate, design and analyse real life problems and develop Mechanical or allied Engineering systems/products/processes. **PSO2:** An ability to implement appropriate design techniques, computer aided engineering tools for modeling, simulation and analysis.

PROGRAM OUTCOMES:

At the end of a programme a students will be able to demonstrate ability to

GRADUATE ATTRIBUTES	PO No.	PROGRAMME OUTCOMES
Research Aptitude	**PO1**	An ability to independently carry out research / investigation, identify problems and develop solutions to solve practical problems.
Technical Documentation	**PO2**	An ability to write and present a substantial technical report / document.
Technical competence	**PO3**	Student should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
Handle complex problems	**PO4**	Use research based knowledge, method, appropriate techniques, resources and tools to solve complex engineering issues with an understanding of the limitations.
Environmental Sustainability and societal ethics	**PO5**	Ensure development of socially relevant and eco-friendly indigenous products by applying technical knowledge, ethical principles and, sound engineering practices.
Life-long learning	**PO6**	Recognize the need for independent, life-long learning and engage in the broadest context of technological change.

MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVES WITH PROGRAMME OUTCOMES

A broad relation between the programme objective and the outcomes is given in the following table

PROGRAMME EDUCATIONAL OBJECTIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
PEO1	3	2	3	3	3	1
PEO2	3	2	3	3	3	1
PEO3	3	2	3	3	3	1

Contribution 1: Reasonable 2: Significant 3: Strong

MAPPING OF PROGRAM SPECIFIC OUTCOMES WITH PROGRAMME OUTCOMES

A broad relation between the Program Specific Objectives and the outcomes is given in the following table

PROGRAMME SPECIFIC OUTCOMES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
PSO1	3	3	2	3	2	2
PSO2	3	3	3	3	3	2

Contribution 1: Reasonable 2: Significant 3: Strong

SEMESTER - I									
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22EDA01	Advanced Mathematics	FC	NIL	3	3	0	0	3
2	22EDA02	Concepts of Engineering Design	FC	NIL	3	3	0	0	3
3	22EDB01	Mechanical Vibrations and acoustics	PC	NIL	3	3	0	0	3
4	22EDB02	Failure Analysis and Design	PC	NIL	3	3	0	0	3
5	22EDB03	Computer Applications in Design	PC	NIL	3	3	0	0	3
6	22EDB04	Design for Manufacture, Assembly and Environments	PC	NIL	3	3	0	0	3
PRACTICALS									
7	22EDP01	Computer Aided Modeling Laboratory	PC	NIL	4	0	0	4	2
8	A1	Audit Course	EEC	Ref. AC	2	2	0	0	0
TOTAL					**24**	**20**	**0**	**4**	**20**

SEMESTER: II									
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22EDB05	Advanced Finite Element Analysis	PC	22EDA01	3	3	0	0	3
2	22EDB06	Mechanisms Design and Simulation	PC	NIL	3	3	0	0	3
3	22EDB07	Integrated Mechanical Design	PC	22EDA01	3	3	0	0	3
4	E01	Elective I	PE	Ref. PE	3	3	0	0	3
5	E02	Elective II	PE	Ref. PE	3	3	0	0	3
6	E03	Elective III	PE/OE	Ref. PE	3	3	0	0	3
PRACTICALS									
7	22EDP02	Analysis and Simulation Laboratory	PC	22EDP01	4	0	0	4	2
8	22EDE01	Technical Seminar	EEC	NIL	4	0	0	4	2
TOTAL					**26**	**18**	**0**	**8**	**22**

SEMESTER: III									
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	E 04	Elective IV	PE	Ref. PE	3	3	0	0	3
2	E 05	Elective V	PE	Ref. PE	3	3	0	0	3
3	E 06	Elective VI	PE	Ref. PE	3	3	0	0	3
PRACTICALS									
4	22EDE02	Project Work Phase - I	EEC	NIL	12	0	0	12	6
5	22EDE03	Industrial Training	EEC	NIL	2	0	0	2	1
				TOTAL	**23**	**9**	**0**	**14**	**16**

SEMESTER: IV									
SL. NO.	**COURSE CODE**	**COURSE TITLE**	**CATEGORY**	**PRE-REQUISITE**	**CONTACT PERIODS**	**L**	**T**	**P**	**C**
THEORY									
1	22EDE04	Project Work Phase - II	EEC	22EDE02	24	0	0	24	12
				TOTAL	**24**	**0**	**0**	**24**	**12**

Total credits to be earned for the award of degree = 20+22+16+12 = 70

FOUNDATION COURSES (FC)

SL. NO.	COURSE CODE	COURSE TITLE	PREREQUISITE	CONTACT PERIODS	L	T	P	C
1	22EDA01	Advanced Mathematics	NIL	3	3	0	0	3
2	22EDA02	Concepts of Engineering Design	NIL	3	3	0	0	3

PROFESSIONAL CORE (PC)

SL. NO.	COURSE CODE	COURSE TITLE	PREREQUISITE	CONTACT PERIODS	L	T	P	C
1	22EDB01	Mechanical Vibrations and acoustics	NIL	3	3	0	0	3
2	22EDB02	Failure Analysis and Design	NIL	3	3	0	0	3
3	22EDB03	Computer Applications in Design	NIL	3	3	0	0	3
4	22EDB04	Design for Manufacture, Assembly and Environments	NIL	3	3	0	0	3
5	22EDP01	Computer Aided Modeling Lab	NIL	4	0	0	4	2
6	22EDB05	Advanced Finite Element Analysis	22EDA01	3	3	0	0	3
7	22EDB06	Mechanisms Design and simulation	NIL	3	3	0	0	3
8	22EDB07	Integrated Mechanical Design	22EDA01	3	3	0	0	3
9	22EDP02	Analysis and Simulation Lab	22EDP01	4	0	0	4	2

PROFESSIONAL ELECTIVES (PE)

SL. NO.	COURSE CODE	COURSE TITLE	PREREQUISITE	CONTACT PERIODS	L	T	P	C
1	22EDX01	Design of Fluid Power systems	NIL	3	3	0	0	3
2	22EDX02	Composite Materials and Mechanics	NIL	3	3	0	0	3
3	22EDX03	Mechanical Behavior of Materials	NIL	3	3	0	0	3
4	22EDX04	Maintenance Engineering	NIL	3	3	0	0	3
5	22EDX05	Design of Material Handling Equipment	NIL	3	3	0	0	3
6	22EDX06	Experimental Stress Analysis	NIL	3	3	0	0	3
7	22EDX07	Advanced Tool Design	22EDB02	3	3	0	0	3

8	22EDX08	Biomechanics	NIL	3	3	0	0	3
9	22EDX09	Mechatronics in Manufacturing Systems	NIL	3	3	0	0	3
10	22EDX10	Bearing Design and Rotor Dynamics	NIL	3	3	0	0	3
11	22EDX11	Additive Manufacturing	NIL	3	3	0	0	3
12	22EDX12	Advanced Metal Forming Techniques	NIL	3	3	0	0	3
13	22EDX13	Optimization Techniques in Design	22EDA01	3	3	0	0	3
14	22EDX14	Computational Fluid Dynamics	22EDA01, 22EDB05	3	3	0	0	3
15	22EDX15	Design of Pressure Vessel and Piping	NIL	3	3	0	0	3
16	22EDX16	Design of Heat Exchangers	NIL	3	3	0	0	3
17	22EDX17	Productivity Management and Re-Engineering	22EDA02	3	3	0	0	3
18	22EDX18	Design for Internet of Things	NIL	3	3	0	0	3
19	22EDX19	Design for Six Sigma	NIL	3	3	0	0	3
20	22EDX20	Advanced Strength of Materials	22EDB01	3	3	0	0	3
21	22EDX21	Tribology in Design	NIL	3	3	0	0	3
22	22EDX22	Nanomaterials and Nano Technology	NIL	3	3	0	0	3
23	22EDX23	Micro Electro Mechanical Systems	NIL	3	3	0	0	3
24	22EDX24	Surface Engineering	NIL	3	3	0	0	3
25	22EDX25	Engineering Fracture Mechanics	22EDB02	3	3	0	0	3
26	22EDX26	Industrial Robotics and Expert systems	NIL	3	3	0	0	3
27	22EDX27	Product Lifecycle Management	NIL	3	3	0	0	3
28	22EDX28	Fuel cell Technology*	NIL	3	3	0	0	3
29	22EDX29	Energy Resources*	NIL	3	3	0	0	3

*** To be ratified in the 12 th BoS meeting**

OPEN ELECTIVES (OE)

SL. NO.	COURSE CODE	COURSE TITLE	PREREQUISITE	CONTACT PERIODS	L	T	P	C
1	22BAZ01	Research Methodology and IPR	OE	3	3	0	0	3
2	22CPZ01	Machine Vision	OE	3	3	0	0	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PRE-REQUISITE	CONTACT PERIODS	L	T	P	C
1	22EDE01	Technical Seminar	EEC	NIL	4	0	0	4	2
2	22EDE02	Project Work Phase - I	EEC	NIL	12	0	0	12	6
3	22EDE03	Industrial Training	EEC	NIL	2	0	0	2	1
4	22EDE04	Project Work Phase - II	EEC	22EDE02	24	0	0	24	12

(a) Audit Courses (AC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PRE-REQUISITE	CONTACT PERIODS	L	T	P	C
1.	22PGA01	English for Research Paper Writing	EEC	NIL	2	2	0	0	0
2.	22PGA02	Disaster Management	EEC	NIL	2	2	0	0	0
3.	22PGA03	Constitution of India	EEC	NIL	2	2	0	0	0

SL. No.	SUBJECT AREA	SUMMARY				
		CREDITS TOTAL				
		I	II	III	IV	TOTAL
1	FC	6	-	-	-	6
2	PC	14	11	-	-	22
3	PE	-	9	9	-	18
4	EEC	-	2	7	12	20
TOTAL		20	22	16	12	70

22EDA01 ADVANCED MATHEMATICS				
L	T	P	C
3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	Acquire knowledge of the random variable and moments & moments generating functions	**1.1**	The students will be able to infer expectation, variance, standard deviation moments and moment generating function for discrete and continuous random variables.
2.0	Aware the knowledge of calculus of variations.	**2.1**	The students will be able to solve problems involving functional, that occurs in various branches of engineering disciplines.
3.0	To understand the method of solving Laplace transform and Fourier transform.	**3.1**	The students will be able to apply Laplace and Fourier transforms to solve initial and boundary value problems in Partial Differential Equations.
4.0	Gain knowledge of solving ordinary differential equations.	**4.1**	The students will be able to solve ordinary differential equations using numerical methods.
5.0	Study numerical solution for solving partial differential equations	**5.1**	The students will be able to solve elliptic partial differential equations by using finite difference methods.

UNIT I : PROBABILITY AND RANDOM VARIABLES	**(9)**
Random variables: Probability mass function – Probability density function – Properties - Moments – Moment generating functions.	
UNIT II : CALCULUS OF VARIATIONS	**(9)**
Calculus Of Variations: Concept of variation and its properties – Euler's equation – Functional dependant on first and higher order derivatives – Functional dependent on functions of several independent variables – Direct methods : Ritz and Kantorovich methods.	
UNIT III: TRANSFORM METHODS	**(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 IV : NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS	**(9)**
Numerical solution of Ordinary differential equations: Runge - Kutta methods for system of IVPs – Numerical stability – Milne's method - Adams Bashforth multistep method – Shooting method.	
UNIT V : NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS	**(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.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Richard Johnson, Miller & Freund's, "Probability and Statistics for Engineers", Eight Edition, Prentice Hall of India Pvt. Ltd., New Delhi, 2011.
2. Veerarajan, T, "Probability, Statistics and Random Process", 3rd Edition,Tata McGraw Hill Publication Company Ltd., 2016.
3. Gupta, A.S, "Calculus of variations with Applications",Prentice Hall of India Pvt.Ltd., New Delhi,1996.
4. Smith, G.D., "Numerical Solutions of Partial Differential Equations: Finite difference Methods", 3rd Edition, Clarendon Press, 1985.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	2	-	1	3	1	1	1	1
2	2	-	1	3	1	1	1	1
3	2	-	1	3	1	1	1	1
4	2	-	1	3	1	1	1	1
5	2	-	1	3	1	1	1	1
CO (W.A)	**2**	**-**	**1**	**3**	**1**	**1**	**1**	**1**

22EDA02 CONCEPTS OF ENGINEERING DESIGN					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					

Course Objectives		Course Outcomes	
1.0	To understand the fundamentals of design process for products	**1.1**	Apply the design concepts in various industrial products based on customer requirements.
2.0	To impart the importance of design in today's context of global competition, environmental awareness and customer oriented market.	**2.1**	Utilize the statistical tools in monitoring the performance of products.
3.0	To understand the various design methods of engineering design	**3.1**	Be familiar with the design concepts to improve the reliability and productivity.
4.0	To understand the selection of proper materials	**4.1**	Apply the material selection process and design for manufacture.
5.0	To impart the basic concepts and various aspects of design using simple examples and case studies.	**5.1**	Gain knowledge about the failure mode effect analysis and green design process.

UNIT I : DESIGN FUNDAMENTALS	**(9)**
Importance of design - Design process - Considerations of good design - Morphology of design - Organization for design – Designing to codes and standards - Product and process cycles - Technological innovation.	
UNIT II : CUSTOMER ORIENTED DESIGN	**(9)**
Identification of customer needs - Customer requirements - Bench marking quality function deployment - Product design specifications - Human factors in design - Ergonomics and aesthetics - Contracts - Product liability - Protecting intellectual property - Legal and ethical domains -Codes of ethics -Ethical conflicts.	
UNIT III : DESIGN METHODS	**(9)**
Creativity and problem solving - Creative thinking methods - Theory of inventive problem solving (TRIZ) - Decision making - Embodiment design - Product architecture - Configuration design - Parametric design - Role of models in design - Rapid prototyping - Finite element analysis - Optimization.	
UNIT IV : MATERIAL SELECTION PROCESSING AND DESIGN	**(9)**
Material selection process - Economics -Weighted property index - Classification of manufacturing process - Design for manufacture - Design for assembly - Designing for castings, Forging, Metal Forming, Machining and Welding - Residual stresses.	
UNIT V : PROBABILITY CONCEPTS IN DESIGN & GREEN DESIGN PROCESS	**(9)**
Probability - Distributions - Test of hypothesis - Design of experiments - Reliability theory - Design for reliability - Robust design - Failure mode effect analysis. Design for environment - Green design process: Material life cycle, embodied energy, carbon footprint, green design in industry, sustainability.	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Dieter George E., "Engineering Design - A Materials and Processing Approach", 4th ed., Tata McGraw Hill, 2013.
2. Pahl, G, and Beitz, W., "Engineering Design", 3rd ed., Springer – Verlag, NY. 2007.
3. Robert C Juvinall, "Fundamentals of Machine Component Design", Wiley, 2011.
4. Suh, N.P., "The Principles of Design", Oxford University Press, NY.1990.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes(PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	1	3	2	1	2	1	2	1
2	2	1	2	1	2	3	3	2
3	2	2	2	2	1	1	3	1
4	1	2	3	2	2	1	2	2
5	1	1	2	1	1	1	3	2
CO (W.A)	**1.4**	**1.8**	**2.2**	**1.4**	**1.6**	**1.4**	**2.6**	**1.6**

22EDB01 MECHANICAL VIBRATIONS AND ACOUSTICS			
L	T	P	C
3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To understand the basic concepts of free and forced vibration with damped and undamped systems	**1.1**	able to analyze response of a SDOF system, damped or undamped, subjected to force excitations
2.0	To determine the natural frequencies and mounting of vibration absorbers in the two degree freedom systems	**2.1**	Identify the solutions for Machine vibration problems with two degree freedom systems using mathematical or numerical analysis.
3.0	To structure the stiffness matrix and calculate the natural frequencies of Multi Degree Freedom System and Continuous System.	**3.1**	Able to write the differential equations of motion for Multi Degree of Freedom and obtain the Eigen-values and mode shapes of natural vibrations
4.0	To recognize the control technique of vibration in machines.	**4.1**	Categorize the causes for vibrations in engineering systems using vibration control and analysis techniques
5.0	To know the terminologies in acoustics and acoustic wave transmission	**5.1**	Illustrate the basics of psychoacoustics, Equal loudness, scale, loudness, pitch loudness and noise.

UNIT I – FUNDAMENTALS AND SIGNLE DEGREE OF FREEDOM	**(9)**
Introduction -Sources Of Vibration – Methods of Vibration Analysis – Types of Vibration - Review Of Single Degree of Freedom Systems - Free vibrations, free damped vibrations, and forced vibrations with and without damping – Vibration Measuring Instruments vibrometers and accelerometer - Response To Arbitrary and non-harmonic Excitations – Transient Vibration – Impulse loads- Critical Speed Of Shaft-Rotor systems.	
UNIT II - TWO DEGREE FREEDOM SYSTEM	**(9)**
Introduction - Free Vibration of Undamped and Damped – Forced Harmonic Vibration – Semi definite System - Coordinate Couplings – Vibration absorber – Torsional vibration absorber – Centrifugal pendulum absorber – Untuned vibration dampers	
UNIT III - MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM	**(9)**
Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method – Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method - Continuous System – Vibration of String, Shafts and Beams.	
UNIT IV – VIBRATION ANALYSIS AND CONTROL	**(9)**
Vibration Analysis Overview - Vibration Measuring Instruments - Selection of Sensors - Accelerometer Mountings. -Vibration Exciters - Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments - Specification of Vibration Limits – Vibration severity standards- Vibration as condition Monitoring Tool-Vibration Isolation methods - Dynamic Vibration Absorber - Static and Dynamic Balancing machines – Field balancing.	

UNIT V - ACOUSTICS	(9)
Psychoacoustics, Speech, mechanism of hearing, thresholds of the ear – sound intensity and frequency, loudness, equal loudness levels, loudness, pitch and timbre, beats, masking by pure tones, masking by noise.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. V.P. Singh, Raveesh Pratap, "Mechanical Vibrations", Dhanpat Rai Publications, New Delhi, 2015
2. Singiresu S Rao "Mechanical Vibrations", Prentice Hall, 2016.
3. Ramamurti.V,"MechanicalVibrationPracticewithBasicTheory",NarosaPublishingHouse, 2010
4. Lawrence E. Kinsler and Austin R.Frey, "Fundamentals of acoustics", Wiley Eastern Ltd., 1987.
5. Michael Rettinger, "Acoustic Design and Noise Control", Vol. I & II. , Chemical Publishing Co., New York, 1977.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) /Programme SpecificOutcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	1	3	3	2	2	1	3	3
2	2	3	2	3	2	2	3	3
3	3	3	2	3	2	2	3	3
4	1	2	1	2	1	2	2	2
5	1	1	1	2	3	1	2	2
CO (W.A)	**1.6**	**2.4**	**1.8**	**2.4**	**2**	**1.6**	**2.6**	**2.6**

22EDB02 FAILURE ANALYSIS AND DESIGN

L	T	P	C
3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To impart knowledge about various modes of failure this leads to materials and design.	**1.1**	Demonstrate the various modes of failure and material behavior in fracture loading.
2.0	To learn about large variety of fracture mechanisms and fracture modes associated with failure.	**2.1**	Examine the fracture mechanisms and fracture, creep, fatigue, corrosion and wear failures.
3.0	To provide an exposure to the students on statistical nature of fatigue and fatigue tests	**3.1**	Implement of fatigue analysis principles in innovative applications.
4.0	To provide fundamental knowledge of corrosion and environmentally-assisted cracking.	**4.1**	Demonstrate the corrosion and wear failure analysis.
5.0	To study about industrial application of failure analysis tools.	**5.1**	Demonstrate the failure analysis tools.

UNIT I : MATERIALS AND DESIGN PROCESS (9)

Factors affecting the behavior of materials in components, effect of component geometry and shape factors, design for static strength, stiffness, designing with high strength and low toughness materials, material selection process, introduction to stress, two dimensional and three-dimensional state of stress, Mohr's circle two and three dimensions, hydrostatic stress, von-Mises, maximum shear stress (Tresca), octahedral shear stress.

UNIT II : FRACTURE MECHANICS (9)

Ductile fracture, brittle fracture, cleavage-fractography, ductile to brittle transition, factors affecting ductile to brittle transition, fracture mechanics approach to design-energy criterion, stress intensity approach, time dependent crack growth and damage - Linear Elastic Fracture Mechanics: Griffiththeory, energy release rate, Instability and R-curve, stress analysis of cracks-stress intensity factor, Crack growth instability analysis.

UNIT III :FATIGUE (9)

Statistical nature of fatigue, signal-noise curve, low cycle fatigue, strain life equations, structural feature of fatigue, fatigue crack propagation, effect of stress concentration, size, surface properties, metallurgical variables on fatigue, case studies, designing against fatigue, detail design, improvements after failure and service, fatigue of bolts, welded and adhesive joints. Fatigue Tests-Purpose, specimen, fatigue test procedures, evaluation of fatigue test results, crack growth measurement. Creep, stress rupture, elevated temperature fatigue, super plasticity.

UNIT IV : CORROSION AND WEAR FAILURES (9)

Types of corrosion, Factors influencing corrosion failures, analysis of corrosion failures, stress corrosion cracking - sources, characteristics of stress corrosion cracking, procedure of analyzing stress corrosion cracking, various types of hydrogen damage failures, corrective and preventive action. Types of wear, lubricated and non – lubricated wear, wear on different materials, different methods of wear measurement. Role of friction on wear, analysis of wear failures, wear tests -ferrography

UNIT V : FAILURE ANALYSIS TOOLS (9)

Reliability concept and hazard function, application of Poisson, exponential and Weibull distribution for reliability, bathtub curve, parallel and series system, failure mode effect analysis - definition-Design, types, process, industrial case studies / Projects.

TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Yiannis Papadopoulos, Engineering failure analysis and design optimization with HiPHOPS" Engineering Failure Analysis, Volume 18, Issue 2, pp 590–608, March 2011.
2. F. Rui, Martins, Failure analysis of bilge keels and its design improvement, Engineering Failure Analysis, Volume 27, pp 232–249, January 2013.
3. T. L. Anderson, Fracture Mechanics: Fundamentals and Applications, CRC Press, 2005.
4. F.Michael and Ashby, Material Selection in Mechanical Design, Butterworth Heinemann, 2004.
5. ASM Metals Handbook, Failure Analysis and Prevention, ASM Metals Park, Ohio, USA, Vol.10, 2002.
6. J.E. Shigley and Mische, Mechanical Engineering Design, McGraw Hill, 2000.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1			1			1		
2	2	2	3	3	1	2		2
3	2	2	3	3	1	2		2
4	2	2	3	3	1	2		2
5			1	1		1		
CO (W.A)	**2**	**2**	**2.2**	**2.5**	**1**	**1.6**		**2**

22EDB03 COMPUTER APPLICATIONS IN DESIGN				
L	T	P	C
3	0	0	3

PREREQUISITE :

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To develop the modeling skills using computer graphic techniques.	**1.1**	Demonstrate computer graphic techniques
2.0	To impart knowledge on CAD software and data exchange standards.	**2.1**	Using CAD software to exchange standards data
3.0	To study the applications of NURBS and solid modeling.	**3.1**	Use of CAD software transfer of product data in various software.
4.0	To gain knowledge on visual realism and computer animation.	**4.1**	Describe the types NURBS and solid modeling
5.0	To provide knowledge on assembly modeling and tolerance analysis.	**5.1**	Demonstrate the knowledge of assembly modeling and tolerance analysis

UNIT I : INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS **(9)**

Output primitives (points, lines, curves etc.) 2D & 3D transformation (Translation, scaling, rotations) windowing - view ports - clipping transformation Open GL Data Exchange standards- IGES, STEP etc. - Communication standards.

UNIT II : CURVES AND SURFACE MODELING **(9)**

Representation of curves - Bezier curves- cubic spline curve - B-Spline curves - Rational curves - Curve manipulations Representation of surface modeling techniques - Analytical surfaces : Plane surface, ruled surface, surface of revolution and tabulated cylinder - synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface - surface manipulation.

UNIT III : NURBS AND SOLID MODELING **(9)**

NURBS - Basics - curves, lines, arcs, circle and bi linear surface Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations constructive solid geometry comparison of representations - user inter face for solid modeling.

UNIT IV : VISUAL REALISM **(9)**

Hidden Line - Surface-solid removal algorithms shading - coloring. Introduction to parametric and variational geometry based software sand the in principles creation of prismatic and lofted parts using the sepackages.

UNIT V : ASSEMBLY OF PARTS **(9)**

Assembly modeling - interferences of positions and orientation - tolerances analysis - mass property calculations- mechanism simulation

TOTAL : L: 45 = 45 PERIODS

REFERENCES:

1. Ibrahim Zeid, "Mastering CAD/CAM", 2nd ed., McGraw Hill, International Edition, 2006.
2. Donald Hearn, M. Pauline Baker, "Computer Graphics", 4th ed., Prentice Hall, Inc., 2010.
3. William M Neumann, Robert F. Sproul, "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.
4. P.Radhakrishnan, C.P.Kothandaraman, "Computer Graphics and Design", Dhanpat Rai and Sons,1999.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	3	1	1	3	-	3	3	1
2	3	1	1	3	-	3	3	1
3	3	1	1	3	-	3	3	1
4	3	1	1	3	-	3	3	1
5	3	1	1	3	-	3	3	1
CO (W.A)	**3**	**1**	**1**	**3**	**-**	**3**	**3**	**1**

22EDB04 DESIGN FOR MANUFACTURE ASSEMBLY AND ENVIRONMENTS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To understand the principles of component design for easy manufacturing	1.1	The students will be able to analyze the given component and identify the suitable geometrical tolerances for manufacturing oriented design.
2.0	To study the factors influencing form design, welding and forging.	2.1	The students will be able to apply the concept of DFM for form design, welding and forging
3.0	To know the casting considerations for manufacturing oriented design	3.1	The students will be able to identify uneconomical design and modify component design for castings
4.0	Apply design considerations for machining	4.1	The students will be able to suggest suitable design modifications to facilitate machining of components
5.0	To expose the impact of design on environment to achieve eco-friendly component design	5.1	The students will be able to use design considerations for environmental issues

UNIT I - INTRODUCTION	(9)
General design principles for manufacturability - Factors influencing design -Types of problems to be solved - evaluation of customer's requirements-Systematic working plan for the designer-Possible solutions - Evaluation method - Process capability - Feature tolerances - Geometric tolerances - Assembly limits - Datum features - Tolerance stacks - Interchangeable part manufacture and selective assembly	
UNIT II - FACTORS INFLUENCING FORM DESIGN	**(9)**
Working principle, Material, Manufacture, Design - Materials choice - Influence of basic design, mechanical loading, material, production method, size and weight on form design- form design of welded members and forgings	
UNIT III - COMPONENT DESIGN – CASTING CONSIDERATION	**(9)**
Form design of grey iron, steel, malleable iron and aluminium castings. Redesign of castings based on parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores.	
UNIT IV - COMPONENT DESIGN - MACHINING CONSIDERATION	**(9)**
Design features to facilitate machining - drills - milling cutters - keyways - Dowelling procedures, counter sunk screws - Reduction of machined area - simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability - Design for accessibility - Design for assembly. Redesign For Manufacture - Identification of uneconomical design - Modifying the design - Group technology - Computer Applications for DFMA	

UNIT V - DESIGN FOR THE ENVIRONMENT	(9)
Introduction - Importance of DFE - Environmental objectives - Global issues - Regional and local issues - Basic DFE methods - Design guide lines - Lifecycle assessment - Basic method - AT&T's environmentally responsible product assessment - Weighted sum assessment method - Techniques to reduce environmental impact - Design to minimize material usage - Design for disassembly - Design for recyclability - Design for remanufacture - Design for energy efficiency - Design to regulations and standards	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Boothroyd G. "Product Design for Manufacture and Assembly". 3rd Edition, CRC Press, London, 2013
2. Boothroyd. G, "Design for Assembly Automation and Product Design", 2nd ed., NewYork, Marcel Dekker, 2005
3. Bralla, "Design for Manufacture handbook", 2nd ed., McGraw hill, 2002
4. Dickson, John. R, and Corroda Poly, "Engineering Design and Design for Manufacture and Structural Approach", Field Stone Publisher, USA, 1995.
5. Fixel, J. "Design for the Environment", McGraw Hill, 1996.
6. Kevien Otto and Kristin Wood, "Product Design", Pearson Publication, 2004.
7. Harry Peck, "Designing for Manufacture", Pitman publishing, 1983

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	2	2	2	3	2	2	2	2
2	3	-	2	3	2	2	2	3
3	2	-	2	3	2	2	2	2
4	3	2	2	3	3	2	2	2
5	2	2	3	2	3	2	2	2
CO (W.A)	**2.4**	**2**	**2.2**	**2.8**	**2.4**	**2**	**2**	**2.2**

22EDP01 COMPUTER AIDED MODELING LABORATORY				
	L	**T**	**P**	**C**
	0	**0**	**4**	**2**

PRE REQUISITE :NIL

Course Objectives		**Course Outcomes**	
1.0	To create the 3D models using modeling software using various commands.	**1.1**	Observe the Industrial Drawing and interpret the data and dimensions.
2.0	Convert 3D solid models into 2D drawing and prepare different views, sections and dimensioning of part models.	**2.1**	Create the 3D models using CAD for various Mechanical components which include parts, assembly etc.
3.0	To understand the concept of assembling Mechanical components using modeling package.	**3.1**	Compute the creative ideas into the CAD model with the consideration of Socio economic problems.
4.0	To impart knowledge on simulation of different mechanisms	**4.1**	Ability to stimulate the vibration of mechanical components using software.
5.0	To know the simulation of physical system using a CAD model of eco- friendly component design	**5.1**	Stimulate the various mechanical link like Four bar mechanism, Cam-Follower Mechanism

- CAD Introduction.
- Sketcher
- Solid modeling – Extrude, Revolve, Sweep, etc and Variational sweep, Loft, etc
- Assembly - Constraints, Exploded Views, Interference check
- Surface modeling –Extrude, Sweep, Trim, etc and Mesh of curves, Free form etc
- Drafting - Layouts, Standard & Sectional Views, Detailing & Plotting.

S.No	LIST OF EXPERIMENT
	MODELING AND ASSEMBLY
1	Modeling and Assembling of Connecting Rod
2	Modeling and Assembling of Tool head of shaper
3	Modeling and Assembling Lever Safety Valve
4	Modeling and Assembling Tailstock of lathe
	MECHANISM SIMULATION
5	Simulation of Spring Damper system
6	Simulation of Four bar mechanism
7	Simulation of Cam-Follower Mechanism
8	Simulation of Crank Slider Mechanism
	TOTAL : P: 45 = 45 PERIODS

Web links for virtual lab (if any)

1. https://www.psmotion.com/mechanism-design-software
2. http://blog.rectorsquid.com/linkage-mechanism-designer-and-simulator/
3. https://www.mscsoftware.com/sites/default/files/Book_Adams-Tutorial-ex17-w.pdf

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme SpecificOutcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	2	1	3	2	1	2	3	1
2	1	1	3	2	1	2	3	2
3	3	2	3	1	3	2	3	2
4	2	2	2	1	1	2	2	2
5	2	2	2	1	1	2	2	1
CO (W.A)	**2**	**1.6**	**2.6**	**1.4**	**1.4**	**2**	**2.6**	**1.6**

22EDB05 ADVANCED FINITE ELEMENT ANALYSIS

L	T	P	C
3	0	0	3

PREREQUISITE :22EDA01

	Course Objectives		Course Outcomes
1.0	To understand the basic principles of the finite element analysis techniques and enhancing the ability to apply the tools of the analysis for solving practical problems arising in Engineering design.	**1.1**	Apply finite elements technique in engineering problem solving for various applications.
2.0	To create expertise in basic elements, one and two dimensional problems.	**2.1**	Derive finite element equation and to solve the real time 1D and 2D structural and thermal problems.
3.0	To create expertise in basic elements of Isoperimetric elements problems.	**3.1**	Solve and analysis the engineering problems using isoparametric and parametric elements.
4.0	To provide knowledge on structural dynamic analysis of bar and beam element	**4.1**	Estimate the solve structural dynamic analysis
5.0	To study the non-linear problems and error estimates of FEM	**5.1**	Create nonlinear problems and error method

UNIT I : ONE-DIMENSIONAL APPLICATIONS	**(9)**
Basic concept of FEM - Weighted residual methods - Variational formulation of B.V.P - Ritz method - Finite element modeling - Element equations - Linear and quadratic shape functions - Bar and beam elements - Bars and beams of arbitrary orientation - Applications to structural heat transfer problems.	
UNIT II : TWO-DIMENSIONAL APPLICATIONS	**(9)**
Poisson equation - Laplace equation - Weak form - Element matrices for triangular and rectangular elements - Evaluation of integrals - Applications – Conduction- and convection heat transfer - Theory of elasticity - Plane strain - Plane stress - Axi-symmetric problems - Principle of virtual displacement.	
UNIT III : ISOPARAMETRIC ELEMENTS	**(9)**
Natural Co-ordinate Systems - Lagrangian Interpolation Polynomials - Isoparametric elements - Quadrilateral elements formulation - Jacobian matrix -Triangular elements - Rectangular elements - Serendipity elements – Numerical Integration - Gauss quadrature - Illustrative Examples.	
UNIT IV : STRUCTURAL DYNAMIC ANALYSIS	**(9)**
Dynamic equations - Consistent and lumped mass matrices - 1D bar element - Formulation of element stiffness, mass and force matrices - Example problems. Natural frequencies - 1D beam element - Formulation of element stiffness, mass matrices.	
UNIT V : NON-LINEAR PROBLEMS AND ERROR ESTIMATES	**(9)**
Introduction - Material non-linearity - Elasto Plasticity - Plasticity - Visco plasticity - Geometric non-linearity - Large displacement - Error norms and convergence rates - H-refinement with adaptivity - adaptive refinement.	
TOTAL (L : 45) :45 PERIODS	

TEXT BOOK:

1. Reddy J.N., "An Introduction to the Finite Element Method", 4rd ed., McGraw Hill, International Edition, 2018.
2. Logan D.L, "A First Course in the Finite Element Method", 6th ed.,Thomson Learning, 2018.

REFERENCES:

1. Cook, Robert Davis et al, "Concepts and Applications of Finite Element Analysis", 4th ed., Wiley, John & Sons, 2007.
2. Chandrupatla, T. R and Belegundu, A.D., "Introduction to Finite Elements in Engineering", 4th ed., Pearson Education, New Delhi, 2018.
3. Rao Singiresu S. "The Finite Element Method in Engineering". 6th Edition, Butterworth-Heinemann, USA, 2017.
4. Bhavikatti SS, "Finite Element Analysis", New Age International Publishers, 2015.
5. Zienkiewicz, O.C. and Taylor, R.L., "The Finite Element Method", 7th ed., McGraw Hill International Edition, Physics Services, 2013.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	1	3	-	-	3	-
2	3	-	1	3	-	-	3	-
3	3	-	1	3	-	-	3	-
4	3	-	1	3	-	-	3	-
5	3	-	1	3	-	-	3	-
CO (W.A)	3	-	-	3	-	-	3	-

22EDB06 MECHANISMS DESIGN AND SIMULATION

L	T	P	C
3	0	0	3

PRE REQUISITE : Nil

	Course Objectives		Course Outcomes
1.0	To learn the fundamentals of kinematics and various mechanisms.	**1.1**	Familiarize with the fundamentals of kinematics and mechanisms.
2.0	To study the complex mechanisms to determine velocity and acceleration of output links.	**2.1**	Determine velocity and acceleration of complex mechanisms.
3.0	To study the path curvature and coupler curves of mechanisms.	**3.1**	Create the path curvature and coupler curves of mechanisms.
4.0	To study the synthesis of mechanisms.	**4.1**	Synthesize the planar mechanisms.
5.0	To learn the design of six bar coupler driven mechanisms and cam mechanisms and to study Simulation Software packages.	**5.1**	Design the six bar coupler driven mechanisms and cam mechanisms.

UNIT I - INTRODUCTION **(9)**

Review of fundamentals of kinematics - classifications of mechanisms-components of mechanisms - mobility analysis - formation of one D.O.F., Compliant mechanisms - Equivalent mechanisms - Basic kinematic structures of serial and parallel robot manipulators

UNIT II - KINEMATIC ANALYSIS **(9)**

Analytical methods for velocity and acceleration Analysis - four bar linkage jerk analysis. Velocity analysis of Plane complex mechanisms using graphical method - Spatial RSSR mechanism - Denavit-Hartenberg Parameters.

UNIT III - PATH CURVATURE THEORY AND COUPLER CURVE **(9)**

Fixed and moving centrodes, inflection points and inflection circle. Hartmann's construction - Euler Savary equation, graphical constructions - Bobbilier constructions - Cubic of stationary curvature. Four bar coupler curve - cusp - crunode - coupler driven six - bar mechanisms - straight line generators.

UNIT IV - SYNTHESIS OF FOUR BAR MECHANISMS **(9)**

Type synthesis - Number synthesis - Dimensional synthesis - function generation, path generation, motion generation. Associated Linkage Concept. Graphical methods- Inversion technique - point position reduction - two, three and four position synthesis of four-bar mechanisms. Analytical methods - Bloch method and Freudenstein's Equation, Mechanism defects.

UNIT V -SYNTHESIS OF COUPLER CURVE BASED MECHANISMS & CAM MECHANISMS **(9)**

Cognate Linkgages - parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell - double stroke. Geared five bar mechanism-multi-dwell. Cam mechanisms- determination of optimum size of cams. Unbalance, Spring surge and Wind up - Study and use of Mechanism using Simulation Software packages.

**** Term Project must be submitted at end of the Semester**

TOTAL (L:45) : 45 PERIODS

TEXT BOOK:

1. Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press. 2017

REFERENCES:

1. Robert L.Norton, "Design of Machinery", Tata McGraw Hill, 2012
2. Sandor G.N. and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Volume II Prentice Hall, 1984.
3. Amitabh A Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi, 2008.
4. Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 2016.
5. Jingshan Zhao Associate Pr, Zhijing Feng, "Advanced Theory of Constraint and Motion Analysis for Robot Mechanisms", Academic Press, 2013.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	1	-	1	1	1	-	1	1
2	1	-	2	3	1	-	2	1
3	1	-	2	3	1	-	2	1
4	1	-	2	3	1	-	2	1
5	1	-	2	3	1	-	2	1
CO (W.A)	1	-	1.8	2.6	1	-	1.8	1

22EDB07 INTEGRATED MECHANICAL DESIGN *(Use of Approved Data Book is Permitted)*					
		L	**T**	**P**	**C**
		3	**0**	**0**	**3**
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To know the integrated design procedure of different machine elements for mechanical applications.	**1.1**	Apply concepts of design of shafts to obtain solutions to real time engineering problems		
2.0	To ensure that the student has thorough conceptual understanding of gear and gear boxes	**2.1**	Identify the gear tooth failure modes and design of gears		
3.0	To study design concepts of dynamics and thermal aspects of brakes and clutches	**3.1**	Integrated design of brakes and clutches for machine tools		
4.0	To study the design of systems consisting of machine elements	**4.1**	Categorize the engineering applications of Integrated design of machine elements		
5.0	To study the design of systems consisting of transmission systems	**5.1**	Apply the concepts of integrated design in transmission systems		

UNIT I : FUNDAMENTALS AND DESIGN OF SHAFTS	**(9)**
Phases of design - Standardization and interchange ability of machine elements - Process and Function Tolerances - Individual and group tolerances - Selection of fits for different design situations - Design for assembly and modular constructions - Concepts of integration - BIS, ISO,DIN, BS, ASTM Standards. Oblique stresses - Transformation Matrix - Principal stresses - Maximum shear stress - Theories of Failure - Ductile vs. brittle component design - Analysis and Design of shafts for different applications - integrated design of shaft, bearing and casing - Design for rigidity	
UNIT II : DESIGN OF GEARS AND GEAR BOXES	**(9)**
Principles of gear tooth action - Gear correction - Gear tooth failure modes - Stresses and loads - Component design of spur, helical, bevel and worm gears - Design for sub assembly - Integrated design of speed reducers and multi-speed gear boxes - application of software packages.	
UNIT III : BRAKES & CLUTCHES	**(9)**
Dynamics and thermal aspects of brakes and clutches - Integrated design of brakes and clutches for machine tools, automobiles and mechanical handling equipments.	
UNIT IV: INTEGRATED DESIGN OF MACHINE ELEMENTS	**(9)**
Integrated Design of systems consisting of shaft, bearings, springs - Design of Elevators, Escalators	
UNIT V: INTEGRATED DESIGN OF TRANSMISSION SYSTEMS	**(9)**
Integrated Design of systems consisting of belt, rope, chain, pulleys, gears, gear boxes, valve gear mechanisms	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:
1. Norton L. R., "Machine Design - An Integrated Approach" Pearson Education, 2019
REFERENCES:
1. Rajamani, Rajesh. Vehicle dynamics and control. Springer Science & Business Media, 2011. 2. Newcomb, T.P. and Spur, R.T., "Automobile Brakes and Braking Systems", Chapman and Hall, 2nd ed., 1975. 3. Maitra G.M., "Hand Book of Gear Design", Tata McGraw Hill, 1985. 4. Shigley, J.E., "Mechanical Engineering Design", McGraw Hill, 1986. 5. Prasad. L. V., "Machine Design", Tata McGraw Hill, New Delhi, 1992. 6. Alexandrov, M., Materials Handling Equipments, MIR Publishers, 1981.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	-	3	-	1	1	1
2	3	-	-	3	-	1	1	1
3	3	-	-	3	-	1	1	1
4	3	-	-	3	-	1	1	1
5	3	-	-	3	-	1	1	1
CO (W.A)	**3**	**-**	**-**	**3**		**1**	**1**	**1**

22EDP02 ANALYSIS AND SIMULATION LABORATORY				
	L	T	P	C
	0	0	4	2

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To impart hands-on training with ANSYS software for solving practical problems arising in engineering design	**1.1**	Compute the engineering problem using a simulation model and find out the solutions
2.0	To simulate the real time problems by using these software and also to understand the application of analysis packages	**2.1**	Get familiarized with the computer aided finite element analysis packages which are necessary to solve the engineering problems numerically
3.0	To develop finite element formulations of engineering problems from a variety of application areas including stress, heat transfer, and vibration analysis	**3.1**	Create the mechanical systems to meet thermal and fluid flow requirements for various applications
4.0	Be aware of the limitations of the FEM. Learn to use ANSYS (Commercial finite element programs)	**4.1**	Usage of commercial FE softwares to solve complex engineering problems with an understanding of their limitations
5.0	To develop the students to perform Design optimization, Buckling, Modal, Fatigue and Harmonic analysis	**5.1**	Demonstrate the mechanical components to meet optimization, Buckling, Modal, Fatigue and Harmonic analysis for various applications

Analysis of Mechanical Components – Use of FEA Packages.

1. Analysis of machine elements under Static loads
2. Analysis of an Axi-symmetric problem
3. Modal and Harmonic Analysis
4. Thermal Analysis of mechanical systems
5. Non-linear Structural Contact Analysis
6. Eigen value Buckling Analysis
7. Fatigue Analysis of a component
8. Modeling a component using Pro/E, Importing to ANSYS and Meshing

• Use of kinematics and dynamics simulation software. Analysis of velocity and acceleration for mechanical linkages of different mechanisms

TOTAL : P: 45 = 45 PERIODS

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	2	1	3	3	1	2	3	1
2	2	1	2	2	1	2	3	1
3	3	2	3	3	2	3	3	2
4	2	2	3	3	2	2	2	2
5	2	2	3	2	2	2	2	2
CO (W.A)	**2.2**	**1.6**	**2.8**	**2.6**	**1.6**	**2.2**	**2.6**	**1.6**

22EDE01 TECHNICAL SEMINAR

L	T	P	C
0	0	4	2

PRE REQUISITE :

	Course Objectives		Course Outcomes
1.0	To offer exposure to the students to refer, read and review the research articles	**1.1**	Review, prepare and present the research articles related to technological developments
2.0	To be aware of the recent technologies	**2.1**	Get practice of oral and written skills.
3.0	To work on a specific technical topic in Engineering design in order to acquire the skills of oral	**3.1**	Improve personal and communicative skills (e.g. speaking, listening, reading, and/or writing).
4.0	To mould students for technical writing abilities for seminars and conferences.	**4.1**	Adequate to understand inductive and deductive reasoning and increase their general problem solving skills.
5.0	To interpret and evaluate the quality of the seminar report	**5.1**	Develop the report and also to develop their presentation skills.

SYLLABUS

The students will work for two hours per week under the guidance of the faculty members. They will be asked to orally present on any topic of their choice related to engineering design and to engage in dialogue with the audience. A brief copy of their oral presentation should be submitted. Similarly, the students will have to present a seminar of not less than fifteen minutes and not more than thirty minutes on the technical topic. They will be answerable to the queries on the topic they present. The students as audience also should interact. Evaluation will be based on the technical presentation, interactive skills and the report they submit.

TOTAL (P:60) : 60 PERIODS

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes(PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	2	1	2	2	1	2	2	1
2	2	1	2	2	1	2	2	1
3	3	1	3	3	1	2	3	1
4	2	1	3	3	1	2	3	1
5	3	2	2	2	2	2	3	2
CO (W.A)	**2.4**	**1.2**	**2.4**	**2.4**	**1.2**	**2.0**	**2.6**	**1.2**

22EDE02 PROJECT WORK PHASE - I				
	L	T	P	C
	0	0	12	6
PRE REQUISITE :				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To identify a specific problem for the current need of the society and collecting information related to the same through detailed review of literature, the methodology to solve the identified problem and preparing project reports and to face reviews and viva-voce examination.	1.1	At the end of the course the students will have a clear idea of their area of work and they will be in a position to carry out the phase II project work in a systematic way.

SYLLABUS:

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

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes(PSOs)

Mapping of COs with POs / PSOs								
COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	3	3	2	2	3	3	3
CO (W.A)	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**

22EDE03 INDUSTRIAL TRAINING				
	L	T	P	C
	0	0	2	1
PRE REQUISITE :				

Course Objectives		Course Outcomes	
1.0	To get familiarity about the discipline of working in a professional engineering organization, communicate with other professional and non-professional groups and apply engineering methods such as design and problem solving.	1.1	The students will have a clear idea in their area of work and they will be in a position to carry out the phase I and phase II project work in a systematic way.

SYLLABUS

- The students will be required to visit minimum of two industries and observe the industry functions.
- The students will be required to present minimum of two technical presentations during this course on current topics related to the specialization.
- The same will be assessed by a committee appointed by the department.
- The students are expected to submit final report based on the above guidelines.

TOTAL (P:30) : 30 PERIODS

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes(PSOs)

Mapping of COs with POs / PSOs								
COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	3	3	2	2	3	3	3
CO (W.A)	3	3	3	3	2	3	3	3

22EDE04 PROJECT WORK PHASE - II				
	L	T	P	C
	0	0	24	12
PRE REQUISITE :				

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To solve the identified problem based on the formulated methodology	1.1	On completion of the project work students will be in a position to take up any challenging practical problem in the field of engineering design and find better solutions to it

SYLLABUS:

The student should continue the phase I work on the selected topic as per the formulated methodology under the same supervisor. At the end of the semester, after completing the work to the satisfaction of the supervisor and review committee, a detailed report should be prepared and submitted to the head of the department. The students will be evaluated based on the report submitted and the viva-voce examination by a panel of examiners including one external examiner

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes(PSOs)

Mapping of COs with POs / PSOs								
COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	3	3	2	2	3	3	3
CO (W.A)	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**

22EDX01 DESIGN OF FLUID POWER SYSTEMS				
	L	T	P	C
	3	0	0	3

PREREQUISITE :

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To impart knowledge on fluid power engineering and power transmission systems	**1.1**	Recognize the use of pumps and actuators in fluid power applications.
2.0	To understand the control elements in fluid power systems and electro-hydraulic systems	**2.1**	Utilize the control and regulation elements in fluid power systems.
3.0	To learn the hydraulic circuits for various industrial applications	**3.1**	Design hydraulic circuits for various industrial applications
4.0	To know the various methods of pneumatic systems and circuits design to solve the real world problems	**4.1**	Identify the various methods of pneumatic systems and circuits design used in industrial applications.
5.0	To gain knowledge about the maintenance of fluid power systems and special circuits.	**5.1**	Perform the installation and maintenance of the fluid power systems and utilize special circuits.

UNIT I : OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS	**(9)**
Fluids - Properties - Types of Fluid power system - Hydraulic Power Generators - Selection and specification of pumps - Pump characteristics. Linear and Rotary Actuators - Selection, Specification and characteristics.	
UNIT II : CONTROL AND REGULATION ELEMENTS	**(9)**
Pressure - direction and flow control valves - relief valves, non-return and safety valves - actuation systems. Electro hydraulic servo valves.	
UNIT III : HYDRAULIC CIRCUITS	**(9)**
Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits – industrial circuits - press circuits - hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits design methodology- design and selection of components - safety and emergency mandrels – Cascade method.	
UNIT IV : PNEUMATIC SYSTEMS AND CIRCUITS	**(9)**
Fundamentals of Pneumatic- Control elements, position and pressure sensing - Logic circuits -Switching circuits - Fringe conditions modules and these integration - Sequential circuits - Cascade methods - Mapping methods - Step counter method - Compound circuit design - Combination circuit design.	
UNIT V : INSTALLATION, MAINTENANCE AND SPECIAL CIRCUITS	**(9)**
Pneumatic equipment - Selection of components - Design calculations - Application - Fault finding - Hydro pneumatic circuits - Use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Antony Espossito, "Fluid Power with Applications", Pearson education 2013.
2. A.Dudley, Pease and J. J. Pippenger, "Basic fluid power", Prentice Hall. 2010
3. Andrew Parr, "Hydraulics and Pneumatics", Jaico Publishing House 2004.
4. Bolton. W., "Pneumatic and Hydraulic Systems", Butterworth - Heinemann, 1997

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	2	1	2	2	1	2	2	1
2	2	1	2	2	1	2	2	1
3	3	1	3	3	1	2	3	1
4	2	1	3	3	1	2	3	1
5	3	2	2	2	2	2	3	2
CO (W.A)	**2.4**	**1.2**	**2.4**	**2.4**	**1.2**	**2.0**	**2.6**	**1.2**

22EDX02 COMPOSITE MATERIALS AND MECHANICS			
L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To understand the fundamentals of composite material strength and its mechanical behaviour.	**1.1**	Describe the properties of various available composite materials.
2.0	Understanding the analysis of fiber reinforced laminate design for different combinations of plies with different orientations of the fiber.	**2.1**	Fabricate the FRP and other composites by different manufacturing methods.
3.0	Thermo-mechanical behavior and study of residual stresses in Laminates during processing.	**3.1**	Analyze fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
4.0	Implementation of Classical Laminate Theory (CLT) to study and analysis for residual stresses in an isotropic layered structure such as electronic chips.	**4.1**	Evaluate the stresses in the lamina of the laminate using different failure theories
5.0	To introduce thermal analysis of composite materials and mechanics	**5.1**	Select suitable composite or thermal analysis for industrial oriented applications.

UNIT I : INTRODUCTION TO COMPOSITE MATERIALS (9)

Definition-Matrix materials - polymers - metals - ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments- ceramic fibers - fiber fabrication- natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate - Reinforced composite Materials, Dispersion - Strengthened composite, Fiber-reinforced composites Rule of mixtures - Characteristics of fiber – Reinforced composites, Manufacturing fiber and composites.

UNIT II : MANUFACTURING OF COMPOSITES (9)

Manufacturing of Polymer Matrix Composites (PMCs) – hand lay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM) - bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) - hot pressing - reaction bonding process - infiltration technique, direct oxidation- interfaces.

UNIT III : INTRODUCTION, LAMINA CONSTITUTIVE EQUATIONS (12)

Lamina Constitutive Equations: Lamina Assumptions - Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina - Isotropic limit case, Orthotropic Stiffness matrix (Qij), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations - Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

UNIT IV : LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT	(8)
Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations - Natural Frequencies.	
UNIT V : THERMO-STRUCURAL ANALYSIS	**(7)**
Fabrication stresses / Residual stresses in FRP laminated composites-Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's - Stress and Moment Resultants due cooling of the laminates during fabrication-Calculations for thermo-mechanical stresses in FRP laminates.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Gibson, R.F., Principles of Composite Material Mechanics, McGraw-Hill, 2016, 4th edition. - CRC press in progress.
2. Mallick, P.K., Fiber -"Reinforced Composites: Materials, Manufacturing and Design", Maneel Dekker Inc, 3rd Edition 2007
3. Hyer, M.W., "Stress Analysis of Fiber - Reinforced Composite Materials", McGraw-Hill,4th edition 2016
4. Issac M. Daniel and Orilshai, "Engineering Mechanics of Composite Materials", Oxford University Press - 2006, First Indian Edition - 2007
5. Mallick, P.K. and Newman, S., (edition), "Composite Materials Technology: Processes and Properties", Hansen Publisher, Munish, 1990.
6. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press(India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
7. Chung, Deborah D.L., "Composite Materials: Science and Applications", Ane Books Pvt. Ltd./Springer, New Delhi, 1st Indian Reprint, 2009

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	2	2	2	3	2	2
2	3	2	2	2	2	3	2	2
3	3	3	3	3	2	3	3	2
4	3	3	3	3	2	3	3	2
5	3	3	2	3	2	3	3	2
CO (W.A)	**3**	**2.6**	**2.4**	**2.6**	**2**	**3**	**2.6**	**2**

22EDX03 MECHANICAL BEHAVIOR OF MATERIALS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

	Course Objectives		Course Outcomes
1.0	To know the mechanical behavior of metallic, non-metallic and modern metallic materials under different loading and temperature conditions	**1.1**	Students will demonstrate an understanding of the mechanical properties and behavior of materials.
2.0	To identify various sources of dynamic loads and design approaches of materials	**2.1**	Gain knowledge in selection of materials for the design of engineering structures.
3.0	To impart knowledge on relationship between materials selection and processing systems	**3.1**	Know the properties and applications of various materials
4.0	To gain knowledge about the modern metallic materials	**4.1**	Demonstrate the ability to identify engineering problems involving plastic deformation, fatigue, and fracture, and the tools required to solve these problems.
5.0	To gain knowledge about the non metallic materials	**5.1**	Familiarize in the area of material behaviour under different loading and temperature conditions.

UNIT I : BASIC CONCEPTS OF MATERIAL BEHAVIOR **(9)**

Elasticity in metals and polymers - Strengthening mechanisms, work hardening, solid solutioning, grain boundary strengthening, poly phase mixture, precipitation, particle, fibre and dispersion strengthening. Effect of temperature, strain and strain rate on plastic behaviour -Super plasticity -Theories of failure - Griffith's theory - Ductile, brittle transition in steel - creep.

UNIT II : BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES **(9)**

Stress intensity factor and fracture toughness - Fatigue, fatigue test, fatigue crack propagation under constant load and variable load mechanisms and Paris law - fail - safe design approaches - Effect of surface and metallurgical parameters on fatigue - Failure analysis, sources of failure, procedure of failure analysis-Impact effects - Notch effects

UNIT III : SELECTION OF MATERIALS **(9)**

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

UNIT IV: MODERN METALLIC MATERIALS **(9)**

Dual phase steels, High strength low alloy (HSLA) steel, Transformation induced plasticity (TRIP) Steel, Maraging steel, Nitrogen steel - Intermetallics, Ni and Ti aluminides, Super plasticity materials - smart materials, shape memory alloys - Metallic glass and nano crystalline materials. Nano structured coatings, thin films, CNT.

UNIT V: NON METALLIC MATERIALS **(9)**

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

TOTAL : L : 45 PERIODS

TEXT BOOK:
1. Meyers, Marc André, and Krishan Kumar Chawla. Mechanical behavior of materials. Cambridge university press, 2008.
REFERENCES:
1. Thomas H. Courtney, Mechanical Behavior of Materials, (2nd ed), McGraw Hill, 2000 2. Flinn, R.A., and Trojan, P.K., "Engineering Materials and their Applications", 4th ed. Jaico, 1999. 3. George E.Dieter, "Mechanical Metallurgy", McGraw Hill, 1988 4. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., "Selection and use of Engineering Materials", 3rd ed., Butterworth- Heiremann, 1997. 5. Metals Hand book, Vol.10, "Failure Analysis and Prevention", 10th ed., Jaico, 1999. 6. Ashby M.F., "Materials selection in Mechanical Design", 2nd ed., Butter worth, 1999.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	-	3	-	2	1	1
2	3	-	-	3	-	2	1	1
3	3	-	-	3	-	2	1	1
4	3	-	-	3	-	2	1	1
5	3	-	-	3	-	2	1	1
CO (W.A)	**3**	**-**	**-**	**3**	**-**	**2**	**1**	**1**

22EDX04 MAINTENANCE ENGINEERING					
		L	T	P	C
		3	0	0	3
PRE REQUISITE :					

Course Objectives		Course Outcomes	
1.0	To enable the student to understand the principles, functions and practices adapted in industry for the successful management of maintenance activities	**1.1**	Demonstrate the basics of maintenance systems
2.0	To explain the different maintenance strategies like Preventive maintenance, condition monitoring and repair of machine elements	**2.1**	Gain ability to plan and schedule maintenanceactivities
3.0	To illustrate some of the simple instrumentsused for condition monitoring	**3.1**	Familiar with the safety and other aspects of maintenance functions
4.0	To learn the planning and scheduling of activitiesin spare Parts management techniques	**4.1**	Establish maintenance strategies according to system characteristics and design transition programs to implement these strategies
5.0	To introduce the safety and other aspects of maintenance functions	**5.1**	Demonstrate different types of accidents and hazards

UNIT I : INTRODUCTION TO MAINTENANCE SYSTEMS	**(9)**
Introduction to repair and Maintenance - Maintenance as business - Maintenance systems such as reactive, preventive, predictive or proactive systems - Human resources management in Maintenance management - maintainability - Inherent and overall availability - Mean time between failures, mean time to repairs and mean down time - Testability and supportability - Design for Maintenance - Poor maintainability aspects - Design for reliability	
UNIT II : CONDITION BASED MAINTENANCE	**(9)**
Condition based monitoring of equipment and systems - condition monitoring techniques such as a) Vibration analysis, b) Ultrasonic detection techniques, c) Thermography, d) Oil and lubricant analysis, e) Motor condition monitoring (MCM) - Shaft alignments through laser - Vibration instruments - Outline on Thermography	
UNIT III : MAINTENANCE TECHNIQUES SUCH AS RCM, TPM & CMMS	**(9)**
Reliability centred Maintenance - Failure Mode and Effect Analysis - Root cause Analysis - logic tree analysis -Criticality matrix - Total Productive Maintenance, Overall Equipment Effectiveness - Lean manufacturing - TPM and TPO - Relationship between OEE and world - class Maintenance - Ladder of Maintenance improvement- Computerized Maintenance management system in a business scenario - data acquisition for effective management of CMMS	
UNIT IV : ASSET PLANNING AND SCHEDULING OF ACTIVITIES IN MAINTENANCE	**(9)**
Asset and spare part management, - Conventional spare Parts management techniques such as Economic Order Quantity, two bin systems - Latest trends in monitoring through bar codes, mobile computer and wireless data transmissions - Different aspects of planning and scheduling of Maintenance, such as shutdowns - Critical aspects of both routine and shut down Maintenance - Bar charts - PERT network during shut down - Man power Training and utilization of skilled manpower - Sequencing of activities	

UNIT V : SAFETY AND OTHER ASPECTS OF MAINTENANCE FUNCTIONS	(9)
Safety Engineering - Hazard analysis - General rules and guidelines in safety and hazard prevention - Analytical tools - Hazard analysis - Fault Tree Analysis - Sneak Circuit analysis - Integrated approach to Maintenance - Statistical distributions such as normal, gamma and Weibull in Maintenance - Maintenance effectiveness	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Venkataraman.K, "Maintenance Engineering and Management", PHI Learning-2007.
2. Kelly. A and Harris, M. J, "Management of Industrial Maintenance", Butter worth & Co., 1978.
3. David J. Smith, "Reliability and Maintainability in Perspective", McMillan, 2nd ed., 1985.
4. Gwidon W Stachowiak and Andrew W. Batchelor, "Engineering Tribology", Butterwork-Heinmann, 2001.
5. John V.Grimaldi & Rollin H.Simonds, "Safety Management", AITBS Publishers & Distributors, 2001

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	1	1	2	2	1	2	2	1
2	2	2	2	2	1	2	2	2
3	1	2	3	3	2	2	3	2
4	1	2	3	3	1	2	2	2
5	2	2	2	2	3	3	3	2
CO (W.A)	**1.4**	**1.8**	**2.4**	**2.4**	**1.6**	**2.2**	**2.4**	**1.8**

22EDX05 DESIGN OF MATERIAL HANDLING EQUIPMENTS
(Use of approved Data Book is permitted)

L	T	P	C
3	0	0	3

PRE REQUISITE :

	Course Objectives		Course Outcomes
1.0	To impart basic concept of material handling	**1.1**	Design the various equipments for material handling in industries.
2.0	To give comprehensive insight in to design of hoists	**2.1**	Determine the requirement of different material handling equipments for various applications.
3.0	To gain knowledge about the drives of hoisting gear	**3.1**	Identify engineering problems and to carry out the engineering design of a design or component to meet desired needs
4.0	To outline the conveyors as a creative art design	**4.1**	Research concept, simulate, test working conditions and applications of modeling methods and their impact on the desired system
5.0	To introduce the rudiments of elevators design principles.	**5.1**	To design the elevators with loading and bucket arrangements in consideration of safety.

UNIT I: MATERIALS HANDLING EQUIPMENT **(9)**

Intraplant transporting facilities - Types - Principle groups of material handling equipment - Choice of material handling equipment - Types of material handling equipment - General characteristics - Applications.

UNIT II : DESIGN OF HOISTS **(9)**

Welded and roller chains - Hemp and wire ropes Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks - crane grabs - lifting magnets - Grabbing attachments - Design of arresting gear - Brakes: shoe, band and cone types.

UNIT III : DRIVES OF HOISTING GEAR **(9)**

Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and monorail cranes - Trackless travelling mechanism - Slewing, jib and luffing gear - cogwheel drive - selecting the motor ratings.

UNIT IV : CONVEYORS **(9)**

Types - description - design and applications of belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

UNIT V : ELEVATORS **(9)**

Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices, stackers - Design of fork lift trucks.

TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Alexandrov, M., "Materials Handling Equipments", MIR Publishers, 2002.
2. R. B.Chowdary and G. R. N.Tagore, "Material Handling Equipments", Khannna Publishers, 2003.
3. Rudenko, N., "Materials Handling Equipment", ELnvee Publishers, 1970..
4. Spivakovsy, A.O. and Dyachkov, V.K., "Conveying Machines, Volumes I and II", MIR Publishers, 1985.
5. Boltzharol, A., "Materials Handling Handbook", The Ronald Press Company, 2009.
6. P.S.G. Tech., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2012.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	3	3	2	3	2	2	3	3
2	3	3	2	3	2	2	2	3
3	3	3	2	3	1	1	2	3
4	3	3	2	3	2	2	2	3
5	3	3	2	3	3	1	3	3
CO (W.A)	**3**	**3**	**2**	**3**	**2**	**1.6**	**2.4**	**3**

22EDX06 EXPERIMENTAL STRESS ANALYSIS					
		L	T	P	C
		3	0	0	3
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To understand the basic aspects of experimental stress analysis.	**1.1**	Recognize the area of application for this method for the health monitoring systems the structures.		
2.0	To understand the emerging techniques like digital image correlation.	**2.1**	Evaluate the stress at the critical points and to measure the severity of damage that occur due to the expose of the structures to the adverse loading condition		
3.0	To understand the fundamental aspects of 3D photo elasticity and digital photo elasticity.	**3.1**	Measure the severity of damage under complex loadings for the load bearing structures		
4.0	To introduce the photo elastic coatings analysis of brittle coatings.	**4.1**	Understand basic principles of photo elasticity, and use it as an analysis tool.		
5.0	To gain knowledge about the non-destructive testing methods.	**5.1**	Aviation of control to develop trend and technique ability by applying the Nondestructive testing methods.		

UNIT I: EXPERIMENTAL STRESS ANALYSIS USING STRAIN GUAGUES	**(9)**
Overview of Experimental Stress Analysis - Optical Methods Work as Optical Computers - Stress - Strain and Displacement Fields. Introduction to Strain Gauges - Strain Sensitivity of a Strain Gauge - Bridge Sensitivity - Rosettes, Strain Gauge Alloys, Carriers and Adhesives. Performance of Strain Gauge System - Temperature Compensation - Two-wire and Three - wire Circuits. Correction Factors for Special Applications - Special Gauges.	
UNIT II : TRANSMISSION PHOTOELASTICITY	**(9)**
Physical Principle of Strain Gauges - Photo elasticity and Moiré - Hologram Interferometry - Speckle Methods - Introduction to Shearography - TSA, DIC and Caustics. Fringe Patterns - Richness of Qualitative Information – Multi - Scale Analysis in Experimental Mechanics, Selection of an Experimental Technique.	
UNIT III : 3D PHOTOELASTICITY AND DIGITAL PHOTOELASTICITY	**(9)**
Introduction to Transmission Photo elasticity - Ordinary and Extraordinary Rays - Light Ellipse, Passage of Light Through a Crystal Plate, Retardation Plates, Stress - optic Law, Determination of Photo elastic Parameters at an Arbitrary Point, Tardy's Method of Compensation, Calibration of Photo elastic Materials, Fringe Thinning Methodologies, Fringe Ordering in Photo elasticity, Miscellaneous Topics in Transmission Photo elasticity, Three Dimensional (3D) Photo elasticity, Overview of Digital Photo elasticity.	

UNIT IV : PHOTOELASTIC COATINGS AND BRITTLE COATINGS	(9)
Introduction to Photo elastic Coatings - Correction Factors for Photoelastic Coatings, Coating Materials - Selection of Coating Thickness, Industrial Application of Photoelastic Coatings, Calibration of Photo elastic Coatings. Introduction to Brittle Coatings - Analysis of Brittle Coatings.	
UNIT V: NON DESTRUCTIVE TESTING METHODS	**(9)**
Load testing on structures, buildings, bridges and towers - Rebound Hammer - Acoustic emission - Sound level meter - Ultrasonic testing principles and application - Holography - use of laser for structural testing - Vibration transducers for velocity and acceleration measurements - Vibrometer - Vibration Analyzer.	
	TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Sadhu Singh - "Experimental Stress Analysis", Khanna Publishers, New Delhi, 2009.
2. JW Dalley and WF Riley, "Experimental Stress Analysis", McGraw Hill Book Company, N.Y. 1991
3. L.S.Srinath et al., "Experimental Stress Analysis", Tata McGraw Hill Company, New Delhi, 1984
4. R.S.Sirohi, HC Radhakrishna, "Mechanical Measurements", New Age International (P) Ltd. 2013

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / ProgrammeSpecific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	3	3	2	3	2	2	3	3
2	3	3	2	3	2	2	3	3
3	3	3	2	3	2	2	2	3
4	2	2	3	3	2	2	2	3
5	3	3	2	3	3	2	3	3
CO (W.A)	**2.8**	**2.8**	**2.2**	**3**	**2.2**	**2**	**2.6**	**3**

22EDX07 ADVANCED TOOL DESIGN					
		L	T	P	C
		3	0	0	3
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To understand the design process and products	**1.1**	Apply the design concepts in various industrial applications		
2.0	To understand the selection of proper materials and design for manufacture.	**2.1**	Gain knowledge about standards in tool design		
3.0	To understand various types of tools and their application.	**3.1**	Design the tools for NC machines		
4.0	To gain proficiency in the development of required views of the final design	**4.1**	Design fixtures for milling, boring, lathe, grinding, welding; identify fixtures and cutting tools for NC machine tools.		
5.0	To gain knowledge about the tool design for numerically controlled machine tools	**5.1**	Describe tool design methods and punch and die manufacturing techniques.		

UNIT I : INTRODUCTION TO TOOL DESIGN	**(9)**
Introduction - Tool Engineering - Tool Classifications - Standards in tool design -Tool Design Objectives - Tool Design in manufacturing - Challenges and requirements - Planning the tool design - Limits and fits - Tooling Materials - Ferrous and Non ferrous Tooling Materials - Carbides, Ceramics and Diamond - Nonmetallic tool materials.	
UNIT II : DESIGN OF DRILL JIGS	**(10)**
Introduction - Fixed Gages - Gage Tolerances - 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.	
UNIT III : DESIGN OF FIXTURES	**(8)**
Introduction - Fixtures and economics - Types of Fixtures - Vise Fixtures - Milling Fixtures - Boring Fixtures - Broaching Fixtures - Lathe Fixtures - Grinding Fixtures.	
UNIT IV :DESIGN OF PRESS TOOL DIES	**(9)**
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 :TOOL DESIGN FOR NUMERICALLY CONTROLLED MACHINE TOOLS	**(9)**
Introduction - Need for numerical control - Basic explanation of numeric control - Numerical control systems in use today (Tool for numerical control machine) - 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 (L:45) : 45 PERIODS	

REFERENCES:

1. B. L. Juneja and G S.Sekhon, "Fundamentals of Metal cutting and Machine tools", New Age International (P) Ltd., New Delhi, 2005.
2. C. Donaldson, G. H.Lecain and V. C.Goold , "Tool Design" , Tata McGraw- Hill, 2007.
3. Edward G.Hoffman , "Jig and Fixture Design", Thomsonasia Pvt Ltd, Singapore, 2004
4. R.A.Lindberg, "Process and Materials of Manufacture", Prentice-Hall of India Pvt. Ltd, New Delhi, 2004.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	3	3	2	3	2	2	3	3
2	3	3	2	3	2	2	2	3
3	3	3	2	3	1	1	2	3
4	3	3	2	3	2	2	2	3
5	3	3	2	3	3	1	3	3
CO (W.A)	**3**	**3**	**2**	**3**	**2**	**1.6**	**2.4**	**3**

22EDX08 BIOMECHANICS					
		L	T	P	C
		3	0	0	3
PRE REQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To gain the knowledge on exposed to principles of mechanics.	**1.1**	Describe the mechanics of physiological systems.		
2.0	To Learn the mechanics of physiological systems.	**2.1**	Classify the bio fluid mechanics.		
3.0	To familiar with the mathematical models used in the analysis of biomechanical systems	**3.1**	Demonstrate the structural properties of hard and soft tissues		
4.0	To understand the characteristics of different types of biomaterials and manufacturing process of implants system.	**4.1**	Design orthopedic applications.		
5.0	To familiarize the students about the various modeling and ergonomics system	**5.1**	Analyze the biomechanical systems.		

UNIT I - INTRODUCTION TO MECHANICS	**(9)**
Principles of Mechanics, Vector mechanics, Mechanics of motion - Newton's laws of motion, Kinetics, Kinematics of motion, Fluid mechanics - Euler equations and Navier Stoke's equations, Visco elasticity, Constitutive equations, Stress transformations, Strain energy function.	
UNIT II - BIOFLUID MECHANICS	**(9)**
Introduction, viscosity and capillary viscometer, Rheological properties of blood, laminar flow, Couette flow and Hagen-poiseuille equation, turbulent flow. Cardiovascular system - biological and mechanical valves development, artificial heart valves testing of valves, Structure, functions, material properties and modeling of Blood vessels.	
UNIT III - BIOSOLID MECHANICS	**(9)**
Hard Tissues: Bone structure & composition mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models - anisotropy. Soft Tissues: Structure, functions, material properties and modeling of Soft Tissues: Cartilage, Tendon, Ligament, Muscle.	
UNIT IV - BIOMECHANICS OF JOINTS AND IMPLANTS	**(9)**
Skeletal joints, forces and stresses in human joints, Analysis of rigid bodies in equilibrium, free body diagrams, types of joint, biomechanical analysis of elbow, shoulder, spinal column, hip knee and ankle. Design of orthopedic implant, specifications for a prosthetic joint, biocompatibility, requirement of a biomaterial, characteristics of different types of biomaterials, manufacturing process of implants, fixation of implants.	

UNIT V - MODELING AND ERGONOMICS	(9)
Introduction to Finite Element Analysis, Analysis of bio mechanical systems using Finite element methods, Graphical design. Ergonomics- Gait analysis, Design of work station, Sports biomechanics, Injury mechanics.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Duane Knudson, "Fundamentals of Biomechanics", 3rd Edition Springer, 2021.
2. Jay D. Humphrey, Sherry De Lange, "An Introduction to Biomechanics: Solids and Fluids, Analysis and Design", Springer Science Business Media, 2004.
3. Marcelo Epstein, "The Elements of Continuum Biomechanics", ISBN: 978-1-119-99923-2, 2012.
4. Shrawan Kumar, "Biomechanics in Ergonomics", Second Edition, CRC Press 2007.
5. Y.C. Fung, "Bio-Mechanics- Mechanical Properties of Tissues", Springer-Verlag, 1998.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	3	-	-	2	2	2	2	2
2	2	2	2	2	2	2	2	2
3	3	-	-	2	-	2	1	2
4	3	-	-	3	3	3	2	2
5	3	-	-	2	2	3	-	2
CO (W.A)	**2.8**	**2**	**2**	**2.2**	**2.25**	**2.4**	**1.75**	**2**

22EDX09 MECHATRONICS IN MANUFACTURING SYSTEMS

L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

	Course Objectives		Course Outcomes
1.0	To develop interdisciplinary knowledge on electronics, electrical, mechanical and computer systems for the design of mechanical and electronic systems.	**1.1**	Identify the Mechatronics approach for designprocess and modeling interdisciplinary systems.
2.0	To acquire knowledge on sensors and transducers used in mechatronics system.	**2.1**	Apply the suitable sensors and transducers to achieve the desired output motion.
3.0	To familiarize with the microprocessors in mechatronics.	**3.1**	Demonstrate the architecture of microprocessor with suitable interfacing components.
4.0	To gain knowledge about the design of fluid power circuits in mechatronics systems	**4.1**	Design the fluid power circuits and analyze the hydraulic systems.
5.0	To gain knowledge about the real timeinterfacing systems.	**5.1**	Analyze the interfacing of sensors, actuators and various instruments involved in mechatronics system.

UNIT I - INTRODUCTION (9)

Introduction to Mechatronics - Systems - Mechatronics in Products - Mechatronics approach for design process, modeling of engineering systems, modeling system with spring, damper and mass, modeling chamber filled with fluid, modeling pneumatic actuator. Transfer functions, frequency response of systems.

UNIT II - SENSORS AND TRANSDUCERS (9)

Sensors for motion and position measurement, force, torque, tactile, temperature sensors, ultrasonic sensors, magnetostrictive sensors.

UNIT III - MICROPROCESSORS IN MECHATRONICS (9)

Introduction - Architecture - Pin configuration - Instruction set - Programming of Microprocessors using 8085 instructions - Interfacing input and output devices - Interfacing D/A converters and A/D converters - Applications - Temperature control - Stepper motor control - Traffic light controller.

UNIT IV - AUTOMATION SYSTEM DESIGN (9)

Design of fluid power circuits - cascade, KV-map and step counter method. PLC - Basic structure - Input / Output processing - Programming of PLC. Sizing of components in pneumatic and hydraulic systems. Analysis of hydraulic circuits.

UNIT V - REAL TIME INTERFACING (9)

Introduction to data acquisition and control systems, overview of I/O process, virtual Instrumentation, interfacing of various sensors and actuators with PC, Condition monitoring, SCADA systems. Traditional Mechatronics design - Designing - Possible design solutions – Case studies of Mechatronics systems.

TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Bolton. W, "Mechatronics - A Multidisciplinary Approach", 4th ed., Pearson Education India, 2016.
2. Devadas Shetty and Richard A. Kolk, "Mechatronics Systems Design", 2nd ed., Cengage Learning India Pvt Ltd, New Delhi , 2012
3. Bradley. D.A, Dawson.D., Buru.N.C. and Loader.A.J., "Mechatronics", Chapman and Hall,2008.
4. Devdas shetty and Richard A.Kolk., "Mechatronics System Design", PWS Publishing Company, USA, 2010.
5. Sabrie soloman, "Sensors and Control System in Manufacturing", McGraw Hill, Inc, 2010.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	1	2	1	3	2	1
2	1	-	-	2	2	2	2	1
3	3	-	3	2	-	2	2	2
4	3	2	2	3	1	2	3	1
5	3	2	2	3	2	2	3	2
CO (W.A)	**2.6**	**1.2**	**1.6**	**2.4**	**1.2**	**2.2**	**2.4**	**1.4**

22EDX10 BEARING DESIGN AND ROTOR DYNAMICS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To know about different types of bearings available for machine design and their operating principles	1.1	Explain the application of various types of bearingsand their operating principles.
2.0	To design hydrodynamic/ hydrostatic / rolling bearing for given specifications and analyze the bearings for their performance	2.1	Design and suggest bearings for specific applications
3.0	To gain knowledge about the selection and design of rolling bearings	3.1	Analyze fatigue life calculations for various types of bearings,
4.0	To introduce dynamics of hydrodynamic bearing design.	4.1	Discuss the dynamics of rotors mounted on Hydrodynamic Bearings
5.0	To know about rotor vibration and design configurations of stable journal bearings	5.1	Identify the vibrating devices, critical speed ofshafts and bearing behavior.

UNIT I - CLASSIFICATION AND SELECTION OF BEARINGS **(6)**

Selection criteria-Dry and Boundary Lubrication Bearings-Hydro dynamic and Hydro static bearings Electro Magnetic bearings-Dry bearings-Rolling Element bearings-Bearings for Precision. Applications-Foil Bearings-Special bearings- Selection of plain Bearing materials –Metallic and Non metallic bearings-Materials for rolling bearings.

UNIT-II DESIGN OF FLUID FILM BEARINGS **(10)**

Design and performance analysis of Thrust and Journal bearings - Full, partial, fixed and pivoted journal bearings design procedure - Minimum film thickness - lubricant flow and delivery - power loss, Heat and temperature distribution calculations - Design based on Charts & Tables and Experimental curves - Design of Foil bearings - Air Bearings - Design of Hydrostatic bearings –Thrust and Journal bearings - Stiffness consideration - flow regulators and pump design.

UNIT III : SELECTION AND DESIGN OF ROLLING BEARINGS **(10)**

Contact Stresses in Rolling bearings – Centrifugal stresses – Elasto hydrodynamic lubrication – Fatigue life calculations- Bearing operating temperature – Lubrication- Selection of lubricants – Internal clearance – Shaft and housing fit- - Mounting arrangements – Materials for rolling bearings-Manufacturing methods – Ceramic bearings – Rolling bearing cages – bearing seals selection.

UNIT IV : DYNAMICS OF ROTORS MOUNTED ON HYDRO DYNAMIC BEARINGS **(10)**

Hydrodynamic Lubrication equation for dynamic loadings-Squeeze film effects in journal bearing sand thrust bearings - Rotating loads , alternating and impulse loads in journal bearings - Journal centre Trajectory - Analysis of short bearings under dynamic conditions - Finite difference solution for dynamic conditions

UNIT V : ROTOR DYNAMICS **(9)**

Rotor vibration and Rotor critical speeds - Support stiffness on critical speeds - Stiffness and damping coefficients of journal bearings - Computation and measurements of journal bearing coefficients - Mechanics of Hydro dynamic Instability – Half frequency whirl and Resonance whip - Design configurations of stable journal bearings

TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Neale, M.J."Tribology Hand Book", Butterworth Heinemann, United Kingdom 2ND edition 2001
2. Cameron, A."Basic LubricationTheory",EllisHerwardLtd.,UK,1981
3. Halling, J.(Editor)–"PrinciplesofTribology",Macmillian–1984
4. Williams J.A."EngineeringTribology",OxfordUniv.Press,1994
5. S.K. Basu, S.N. Sengupta & B.B. Ahuja ,"Fundamentals of Tribology", Prentice –Hall of IndiaPvtLtd,NewDelhi,2005 6 G.W. Stachowiak & A.W.Batchelor,EngineeringTribology,Butterworth-Heinemann,UK,2005

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	3	2	2	2	2	2	2
2	3	3	2	2	2	2	3	2
3	3	3	2	3	2	3	3	2
4	3	3	2	2	2	3	2	2
5	3	2	1	2	2	3	2	2
CO (W.A)	**3**	**2.8**	**1.8**	**2.2**	**2**	**2.6**	**2.4**	**2**

22EDX11 ADDITIVE MANUFACTURING				
	L	T	P	C
	3	0	0	3

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To educate students with fundamental and advanced knowledge in the field of additive manufacturing technology.	1.1	The students are expected to learn about a varietyof Additive Manufacturing (AM) technologies.
2.0	Gain insights on the need, advantages and limitations of additive manufacturing versus traditional manufacturing	2.1	Find the appropriate fabrication technology while considering the reverse engineering and CAD modelling.
3.0	Find out the various applications of additive manufacturing, Deployment levels, innovativeand optimized product design.	3.1	Identify the liquid based and solid based additive manufacturing systems for a specific application.
4.0	To explore the potential of additive manufacturing in different industrial sectors.	4.1	Select the powder based additive manufacturing systems for a specific application.
5.0	To apply 3D printing technology for additive manufacturing	5.1	Elaborate 3D printing, Shape Deposition Manufacturing processes and their applications.

UNIT I : INTRODUCTION	**(9)**
Need - Development of AM systems – AM process chain - Impact of AM on Product Development - Virtual Prototyping- Rapid Tooling – RP to AM -Classification of AM processes-Benefits- Applications.	
UNIT II : REVERSE ENGINEERING AND CAD MODELLING	**(9)**
Basic concept- Digitization techniques – Model reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data requirements – Geometric modelling techniques: Wire frame, surface and solid modelling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing, Tool path generation- Software for AM- Case studies.	
UNIT III : LIQUID BASED AND SOLID BASED ADDITIVE MANUFACTURING SYSTEMS	**(12)**
Stereo lithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, part quality and process planning, recoating issues, materials, advantages, limitations and applications. Solid Ground Curing (SGC): working principle, process, strengths, weaknesses and applications. Fused deposition Modelling (FDM): Principle, details of processes, process variables, types, products, materials and applications. Laminated Object Manufacturing (LOM): Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.	
UNIT IV : POWDER BASED ADDITIVE MANUFACTURING SYSTEMS	**(8)**
Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy, Applications. Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications– Case Studies.	

UNIT V : OTHER ADDITIVE MANUFACTURING SYSTEMS	(7)
Three-dimensional Printing (3DP): Principle, basic process, Physics of 3DP, types of printing, process capabilities, material system. Solid based, Liquid based and powder based 3DP systems, strength and weakness, Applications and case studies. Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting.	
TOTAL (L:45) : 45 PERIODS	

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.
4. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
5. Fuewen Frank Liou., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2019.
6. Milan Brandt., "Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications", Wood head Publishing, UK, 2016. ISBN- 9780081004333.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	2	2	2	3	2	2
2	3	2	2	2	2	3	2	2
3	3	3	3	3	2	3	3	2
4	3	3	3	3	2	3	3	2
5	3	3	2	3	2	3	3	2
CO (W.A)	**3**	**2.6**	**2.4**	**2.6**	**2**	**3**	**2.6**	**2**

22EDX12 ADVANCED METAL FORMING TECHNIQUES				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To study the concepts of latest metal forming techniques and their applications in metal forming industry.	**1.1**	Acquire the basics of plasticity and forming
2.0	To study the thermo mechanical regimes and its requirements of metal forming	**2.1**	Classify the basic metal forming techniques, forging, extrusion, drawing and rolling.
3.0	To gain knowledge about the sheet metal forming process	**3.1**	Fabricate the product using sheet metal forming with conventional process.
4.0	To gain knowledge about the powder metallurgy and special forming processes	**4.1**	Fabricate basic parts and assemblies using powder and non- powder machine shop equipment in conjunction
5.0	To develop a thorough understanding of the electromagnetic forming and its applications	**5.1**	Acquire the basics of production by using electromagnetic forming

UNIT I: INTRODUCTION TO THEORY OF PLASTICITY AND FORMING	**(9)**
Theory of plastic deformation - Yield criteria - Tresca and Von-mises - Distortion energy - Stress strain relation - Mohr's circle representation of a state of stress - cylindrical and spherical coordinate system - upper and lower bound solution methods - thermo pelastic Elasto plasticity - Elasto Visco plasticity.	
UNIT II : THEORY AND PRACTICE OF BULK FORMING PROCESSES	**(9)**
Analysis of plastic deformation in Forging, Rolling, Extrusion, rod/wire drawing and tube drawing - Effect of friction -calculation of forces, work done - Process parameters, equipment used - Defects - applications - Recent advances in Forging, Rolling, Extrusion and Drawing processes - Design consideration in forming - Formability of laminated sheet - Overview of FEM applications in metal forming analysis.	
UNIT III : SHEET METAL FORMING	**(9)**
Formability studies - Conventional processes - H E R F techniques - Super plastic forming techniques - Hydro forming - Stretch forming - Water hammer forming - Principles and process parameters - Advantage, Limitations and application.	
UNIT IV : POWDER METALLURGY AND SPECIAL FORMING PROCESSES	**(9)**
Overview of P/M technique - Advantages - applications - Powder perform forging - powder rolling - Tooling, process parameters and applications - Orbital forging - Isothermal forging - Hot and cold isostatic pressing - High speed extrusion - Rubber pad forming - Fine blanking - LASER beam forming.	
UNIT V : ELECTROMAGNETIC FORMING AND ITS APPLICATIONS	**(9)**
Electromagnetic forming process - Electro - magnetic forming machines - Process variables - Coils and Dies - Effect of resistivity and geometry - EM tube and sheet forming, stamping, shearing and welding - Applications - Finite element analysis of EM forming.	
TOTAL : L : 45 = 45 PERIODS	

REFERENCES :

1. Shiro Kobayashi; Soo-Ik Oh; Taylan Altan, T, Metal forming and Finite Element Method, New York : Oxford University Press, 2020
2. Dieter G.E., Mechanical Metallurgy (3rd Edition) McGraw Hill Co., 1st July 2017
3. Altan.T, Soo-Ik-Oh, Gegel, HL – Metal forming, fundamentals and Applications, Metals Park, Ohio : American Society for Metals, 2000, 7th printing
4. Altan T., Metal forming – Fundamentals and applications – American Society of Metals, Metals park, 2003.
5. ASM Hand book, Forming and Forging, Ninth edition, Vol – 14, 2003
6. Marciniak,Z., Duncan J.L., Hu S.J., 'Mechanics of Sheet Metal Forming', Butterworth-Heinemann An Imprint of Elesevier, 2006
7. SAE Transactions, Journal of Materials and Manufacturing Section 5, 1993-2007

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	2	3	1	2	-	3
2	3	1	3	2	-	1	1	2
3	3	-	2	1	1	-	-	2
4	2	-	2	1	2	-	-	2
5	2	-	1	2	-	-	1	2
CO (W.A)	2.6	1	2	1.8	1.3	1.5	1	2.2

22EDX13 OPTIMIZATION TECHNIQUES IN DESIGN				
L	T	P	C	
3	0	0	3	

PRE REQUISITE : 17EDA01

Course Objectives		Course Outcomes	
1.0	To get knowledge on minimization methods namely elimination methods, interpolation methods and direct root methods	**1.1**	Solve one dimensional minimization problems using elimination or interpolation methods
2.0	To get exposed various unconstrained and constrained minimization methods	**2.1**	Optimally derive solutions for constrained /unconstrained optimization problems using appropriate method
3.0	To provide an exposure on the design applications of geometric and stochastic programming.	**3.1**	Ability to portray the methods of optimization techniques (direct and indirect methods)
4.0	To be familiar with various modern optimization techniques	**4.1**	Express the steps involved in geometric, Stochastic programming and modern methods of optimization.
5.0	To gain knowledge about the modern methods of optimization techniques.	**5.1**	Reveal the knowledge of modern methods of optimization.

UNIT I - UNIT I : ONE DIMENSIONAL MINIMIZATION METHODS	**(9)**
Unimodal function - Elimination methods -unrestricted search - exhaustive search - dichotomous search - interval halving method - ibonacci method - golden section method - interpolation methods-quadratic and cubic interpolation methods - direct root methods - Newton method - Quasi Newton method - secant method	
UNIT II - UNCONSTRAINED OPTIMIZATION TECHNIQUES	**(9)**
Classification of unconstrained minimization methods - direct search methods - random walk method - univariate method - Powell's method - simplex method - Indirect search methods - steepest descent method - Fletcher - Reeves method - Newton's method - Marquardt method - Broyden-Fletcher-Goldfarb-Shanno (BFGS) Method	
UNIT III - CONSTRAINED OPTIMIZATION TECHNIQUES	**(9)**
Direct Methods - Sequential Linear Programming(SLP) - Zoutendijk's method of feasible directions - Rosen's gradient projection method - Generalized Reduced Gradient (GRG) method - sequential quadratic programming - Indirect Methods - interior penalty function method - exterior penalty function method - Augmented Lagrange Multiplier (ALM) method	
UNIT IV - GEOMETRIC AND STOCHASTIC PROGRAMMING	**(9)**
Unconstrained geometric programming problem - differential calculus method - arithmetic-geometric inequality method - constrained geometric programming problem - mixed inequality constraints - applications - formulation of geometric programming problems of design of hydraulic cylinder and helical spring - Stochastic nonlinear programming and geometric programming in design	

UNIT V - MODERN METHODS OF OPTIMIZATION	(9)
Genetic algorithms - Simulated annealing - Particle swarm optimization - Ant colony optimization - Optimization of fuzzy systems – Neural - Network - Based Optimization.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Rao.S.S, "Engineering Optimization – Theory and Practice", New age publishers, 2013.
2. Ashok D. Belegundu, Tirupathi R. Chandrupatla, "Optimization Concepts and Applications in Engineering", 2nd ed., Cambridge University Press, 2014.
3. Kalyanamoy Deb, "Optimization for Engineering Algorithms and Examples", Prentice Hall of India, 2012.
4. Charles L. Byrne, "A First Course in Optimization", CRC Press, 2015.
5. Edwin K.P Chong, Stanislaw H. Zak, "An Introduction to Optimization", 4th ed., John Wiley & Sons, 2013.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	3	2	1	3	1	1	3	2
2	3	2	1	3	1	1	3	2
3	3	2	1	3	1	1	3	2
4	3	2	1	3	1	1	3	2
5	3	2	1	3	1	1	3	2
CO (W.A)	**3**	**2**	**1**	**3**	**1**	**1**	**3**	**2**

22EDX14 COMPUTATIONAL FLUID DYNAMICS					
		L	T	P	C
		3	0	0	3
PREREQUISITE : NIL					
Course Objectives		**Course Outcomes**			
1.0	To introduce governing equations of fluid flows.	**1.1**	Classify the basic equations of computational fluid dynamics		
2.0	To introduce numerical modeling and its role in the field of fluid flow and heat transfer.	**2.1**	Solve complex problems in the field of heat transfer.		
3.0	To enable the students to understand the various discretization methods, solution procedures and turbulence modeling.	**3.1**	Solve complex problems in the field of CFD		
4.0	To apply the concepts to the finite volume method for convection diffusion	**4.1**	Analyze convective problems using computational methods.		
5.0	To give detailed study of calculation flow field by FVM	**5.1**	Examine and assessing basic numerical methods for fluid flow problems.		

UNIT I : GOVERNING EQUATIONS AND BOUNDARY CONDITIONS	**(3)**
Basics of computational fluid dynamics - Governing equations of fluid dynamics - Continuity, Momentum and Energy equations - Physical boundary conditions - Time-averaged equations for Turbulent Flow - Turbulent - Kinetic Energy Equations - Mathematical behavior of PDEs on CFD - Elliptic, Parabolic and Hyperbolic equations.	
UNIT II : FINITE DIFFERENCE METHOD	**(12)**
Derivation of finite difference equations - Simple Methods - General Methods for first and second order accuracy - solution methods for finite difference equations - Elliptic equations - Iterative solution Methods - Parabolic equations - Explicit and Implicit schemes - Example problems on elliptic and parabolic equations	
UNIT III : FINITE VOLUME METHOD (FVM) FOR DIFFUSION	**(12)**
Finite volume formulation for steady state one, two and three - dimensional diffusion problems. One dimensional unsteady heat conduction through explicit, Crank - Nicolson and fully implicit schemes.	
UNIT IV : FINITE VOLUME METHOD FOR CONVECTION DIFFUSION	**(9)**
Steady one-dimensional convection and diffusion - central, upwind differencing schemes-properties of discretization schemes - conservativeness, boundedness, trasnportiveness, hybrid, power-law, quick schemes.	
UNIT V : CALCULATION FLOW FIELD BY FVM	**(9)**
Representation of the pressure gradient term and continuity equation - Staggered grid - Momentum equations - Pressure and Velocity corrections - Pressure Correction equation, Simple algorithm and its variants. Turbulence models, mixing length model, two equation (k-) models - High and low Reynolds number models.	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Versteeg, H.K., and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", 2008.
2. T.J. Chung, "Computational Fluid Dynamics", Cambridge University Press, 2014.
3. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw Hill Publishing Company Ltd., 1998.
4. Patankar, S.V. "Numerical Heat Transfer and Fluid Flow", Hemisphere Publishing Corporation, 2017.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	2	2	2	2	1	2	3	2
2	2	2	2	2	1	2	3	2
3	3	2	3	2	1	2	3	2
4	3	2	3	2	1	2	3	2
5	3	2	2	2	1	2	3	2
CO (W.A)	**2.6**	**2**	**2.4**	**2**	**1**	**2**	**3**	**2**

22EDX15 DESIGN OF PRESSURE VESSEL AND PIPING

L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

	Course Objectives		Course Outcomes
1.0	To educate the means of flow distribution and stress analysis in pressure vessels.	**1.1**	Predict the thermal behavior and carry out a stress analysis in pressure vessels.
2.0	To understand the stress analysis of piping layout	**2.1**	Design the pressure vessels and piping layout for industrial applications.
3.0	To get a basic understanding of the design of vessels	**3.1**	Analyze the failure of pressure vessels and safety measures taken for avoiding failure
4.0	To study the buckling and fracture analysis in vessels	**4.1**	Determine the stresses in pressure vessels to design the system.
5.0	To learnt piping layout and piping stress analysis	**5.1**	To create the flow diagram and layout of piping with consideration of stress and thermal analysis.

UNIT I : INTRODUCTION	**(9)**
Methods for determining stresses - Terminology and Ligament Efficiency - Applications.	
UNIT II : STRESSES IN PRESSURE VESSELS	**(9)**
Introduction - Stresses in a circular ring, cylinder - Membrane stress Analysis of Vessel Shell components - Cylindrical shells, spherical Heads, conical heads - Thermal Stresses - Discontinuity stresses in pressure vessels.	
UNIT III : DESIGN OF VESSELS	**(9)**
Design of Tall cylindrical self-supporting process columns - supports for short vertical vessels - stress concentration - variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement - pressure vessel Design.	
UNIT IV : BUCKLING AND FRACTURE ANALYSIS IN VESSELS	**(9)**
Buckling phenomenon - Elastic Buckling of circular ring and cylinders under external pressure - collapse of thick walled cylinders or tubes under external pressure - Effect of supports on Elastic Buckling of Cylinders - Buckling under combined External pressure and axial loading.	
UNIT V : PIPING	**(9)**
Introduction - Flow diagram - Piping layout and piping stress analysis.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. John F. Harvey, "Theory and Design of Pressure Vessels", CBS Publishers and Distributors, 2001.
2. Dennis R. Moss and Michael M. Basic, "Pressure Vessel Design manual", Butterworth- Heinemann, Fourth Edition, 2013.
3. Stanley, M. Wales, "Chemical process equipment, selection and Design", Butter worths series in Chemical Engineering, 2022.
4. Somnath Chattopadhyay, "Pressure Vessels - Design and Practice", CRC Press, 2004
5. William. J., Bees, "Approximate Methods in the Design and Analysis of Pressure Vessels and Piping", Proceedings ASME Pressure Vessels and Piping Conference, 1997.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / ProgrammeSpecific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	3			2	1	2
2	3	2	2	2		3	2	2
3	3	1	2		2	1	1	
4	2	2	3	2		2		1
5	3	3	3	3	2	2	3	2
CO (W.A)	2.8	2	2.6	2.3	2	2	1.75	1.75

22EDX16 DESIGN OF HEAT EXCHANGERS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To build the necessary background for the design of the various types of heat exchangers.	1.1	Apply the concepts and knowledge get to design and analyze the sizing and rating of the heat
2.0	To learn the thermal and stress analysis on various parts of the heat exchangers.	2.1	Solve the efficiency of heat exchanger in various heat transfer methods.
3.0	To learn the sizing of heat exchangers, thermal and mechanical stress analysis for various heat exchange applications.	3.1	Analyze heat transfer rate depending on nature of problem and available data
4.0	To impart knowledge on compact and plate heat exchangers	4.1	Design and performance calculations of plate heat exchanger.
5.0	To improve the design knowledge in condensers & cooling towers	5.1	Ability to design and analyze the performance of the condensers and cooling towers.

UNIT I : FUNDAMENTALS AND CLASSIFICATION OF HEAT EXCHANGER	**(9)**
Parallel flow, Counter flow and cross flow; shell and tube and plate type; single pass and multi pass, once through stream generators etc.	
UNIT II : PROCESS DESIGN OF HEAT EXCHANGERS	**(9)**
Heat transfer correlations, Overall heat transfer coefficient, LMTD, sizing of finned tube heat exchangers, U tube heat exchangers, fouling factors, pressure drop calculations.	
UNIT III : MECHANICAL DESIGN OF SHELL AND TUBE TYPE	**(9)**
Thickness calculations, Tube sheet design using TEMA formula, Concept of equivalent plate for analyzing perforated analysis, flow induced vibration risks including acoustic issue and remedies, tube to tube sheet joint design, buckling of tubes, thermal stresses	
UNIT IV : COMPACT AND PLATE HEAT EXCHANGERS	**(9)**
Types - merits and demerits - design of compact heat exchangers, plate heat exchangers - performance influencing parameters, limitations.	
UNIT V : CONDENSERS & COOLING TOWERS	**(9)**
Design of surface and evaporative condensers - cooling tower - performance characteristics.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. SadikKakac, Hongtan Liu, Anchasa Pramuanjaroenkij, "Heat Exchangers Selection, Rating and Thermal Design", CRC Press, Third Edition, 2012.
2. Hewitt.G.F, Shires.G.L, Bott.T.R, Process Heat Transfer, Begell House, Inc. Publishers, 2021
3. Ramesh K.Shah, Dušan P.Sekulić, "Fundamentals of heat exchanger design", John Wiley & Sons, 2003.
4. Robert W. Serth, "Process heat transfer principles and applications", Academic press, Elesevier, 2010.
5. T. Kuppan, "Heat exchanger design hand book", New York: Marcel Dekker, 2009.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / ProgrammeSpecific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3		3	3	2	3	3	
2	3	3	1	3	1	2	3	3
3	3	1	2	1	3	1	2	1
4	2	2		1		2	1	2
5	3	2	2	2	2	3	2	2
CO (W.A)	2.8	2	2	2	2	2.2	2.2	2

22EDX17 PRODUCTIVITY MANAGEMENT AND RE-ENGINEERING				
L	T	P	C	
3	0	0	3	

PRE REQUISITE : Nil

Course Objectives		Course Outcomes	
1.0	To understand the productivity and its measurement in various levels	1.1	To use the productivity measurement in International. National and industrial levels
2.0	To know the productivity planning	2.1	To make short term and long term productivity planning in organizations
3.0	To understand the organizational transformation and re- engineering	3.1	To familiarise with organizational transformation and re- engineering
4.0	To understand the use of Re-engineering process improvement tools	4.1	To use Re-engineering process improvement tools
5.0	To impart knowledge at re- engineering tools and implementation of reengineering projects	5.1	To Implement the reengineering projects in commercial purpose.

UNIT I: PRODUCTIVITY	**(9)**
Productivity - Factor affecting productivity - Productivity benefit model - Productivity Cycle - Productivity Measurement at International, National and Industrial level.	
UNIT II : PRODUCTIVITY PLANNING IN ORGANIZATIONS	**(9)**
Productivity planning: Importance - Short term versus long term - Responsibilities - Weighted partial productivity- Production evaluation tree - Long term - Total Productivity maximization model - Total Productivity Profit model.	
UNIT III : ORGANIZATIONAL TRANSFORMATION	**(9)**
Principles of organizational transformation and re-engineering - Six R'S of organizational transformation and reengineering - fundamentals of process re-engineering - Preparing the workforce for transformation and reengineering - Principle &methodology- Guidelines - LMI CIP Model.	
UNIT IV : RE-ENGINEERING PROCESS IMPROVEMENT MODELS	**(9)**
PMI models, Moen and Nolan Strategy for process improvement, LMICIP personal improvement model-NPRDC process improvement model.	
UNIT V : RE-ENGINEERING TOOLS AND IMPLEMENTATION	**(9)**
Analytical and process tools and techniques - Information and Communication Technology - Implementation of Reengineering Projects - Success Factors and common implementation Problem - Case studies.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:
1. Sumanth, D.J., "Productivity Engineering and Management", TMH, New Delhi, 2007.
REFERENCES:
1. Edosomwan, J.A., "Organisational Transformation and Process Re-engineering", Library Catalog 1995. 2. Rastogi, P.N., "Re-engineering and Re-inventing the Enterprise", Wheeler Pub. New Delhi, 1995. 3. Premvrat, Sardana, G.D. and Sahay, B.S., "Productivity Management – A Systems Approach", Narosa Publishing House. New Delhi, 1998.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / ProgrammeSpecific Outcomes (PSOs)

COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	1	-	1	1	2	-	1	-
2	1	-	1	1	2	-	2	1
3	1	-	1	1	2	3	3	1
4	1	-	1	1	2	-	2	-
5	1	-	1	1	2	3	1	1
CO (W.A)	**1**	**-**	**1**	**1**	**2**	**3**	**1.8**	**1**

22EDX18 DESIGN FOR INTERNET OF THINGS			
L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To integrate the concepts of Machine to Machine (M2M) to IoT	**1.1**	Find out the vision of IoT from a global context.
2.0	To know the devices in IoT market perspective technology	**2.1**	Determine the market perspective of IoT with standards considerations.
3.0	To learnt concepts of IoT networking	**3.1**	Identify the devices, gateways and data management in the IoT networking.
4.0	To impart knowledge on state of art IoT architecture	**4.1**	Build the architecture reference model in IoT.
5.0	To know the Integrating of architecture modeling and industrial automation	**5.1**	Apply IoT in an industrial and commercial building automation and real world design constraints.

UNIT I - INTRODUCTION	**(9)**
Machine to Machine (M2M) to IoT- vision-introduction, from M2M to IoT, M2M towards IoT- global context, An use caseexample, differing characteristics.	
UNIT II - IoT STRUCTURE	**(9)**
M2M to IoT - A Market Perspective - Introduction, some definitions, M2M value chains, IoT value chains, an emergingindustrial structure for IoT, international driven global value chain and global information monopolies. **M2M to IoT**- An Architectural Overview - Building an architecture, main design principles and needed capabilities, IoT architecture outline, standards considerations.	
UNIT III - IoT NETWORKING	**(9)**
M2M and IoT Technology Fundamentals - Devices and gateways, local and wide area networking, data management,business processes in IoT, everything as a service (XaaS), M2M and IoT analytics, knowledge management.	
UNIT IV - IoT ARCHITECTURE	**(9)**
IoT Architecture - State of the Art - Introduction, State of the art, Architecture Reference Model - Introduction, reference model and architecture, IoT reference model.	
UNIT V - ARCHITECTURE MODELING	**(9)**
IoT Reference Architecture - Introduction, Functional view, Information view, deployment and operational view, other relevant architectural views. **Real-World Design Constraints** - Introduction, technical design constraints-hardware is popular again, data representation and visualization, Interaction and remote control. **Industrial Automation** - service - oriented architecture-based device integration, **SOCRADES:** realizing the enterprise integrated web of things, **IMC-AESOP:** from the web of things to the cloud of things, **Commercial Building Automation** - Introduction, case study: phase one- commercial building automation today, case study: phase two- commercial building automation in the future.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Francis daCosta, "Rethinking the Internet of Things: A Scalable Approach to Connecting Everything", 1st ed , A press Publications, 2013.
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, Stamatis Karnouskos, David Boyle, "From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence", 1st ed , Academic Press, 2014.
3. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1st ed , VPT, 2014.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	1	2	1	3	1	2
2	3	2	-	-	2	3	1	2
3	2	2	-	-	2	2	2	2
4	3	2	-	-	-	3	2	1
5	2	2	2	1	1	2	1	1
CO (W.A)	**2.6**	**2**	**1.5**	**1.5**	**1.5**	**2.6**	**1.4**	**1.6**

22EDX19 DESIGN FOR SIX SIGMA					
		L	T	P	C
		3	0	0	3
PRE REQUISITE :					

Course Objectives		Course Outcomes	
1.0	To gain insights about the importance of lean manufacturing and six sigma practices	**1.1**	Understand Six Sigma Methodology and how it applies to their day-to-day work.
2.0	To gain knowledge of improving define phase in production process	**2.1**	Relate the tools and techniques of lean sigma to increase productivity.
3.0	To gain knowledge of humanizing measure and analysis phase.	**3.1**	Familiar with methodology to produce products with minimum wastages and maximum Productivity
4.0	To impart knowledge on design phase of six sigma	**4.1**	Get familiarized in six sigma.
5.0	To impart knowledge on validate phase	**5.1**	Ability to create the control chart, analysis performance with Simulation

UNIT I : INTRODUCTION TO SIX SIGMA	**(9)**
Introduction to Six sigma, Project charter, PPM calculator, Gauge R&R , Linear Regression, One / Two way ANOVA, Assembly toleranceing, Basic Control charts, Case studies.	
UNIT II : DEFINE PHASE	**(9)**
Customer CTQ, QFD, Standardization, Reactive design to Predictive design quality.	
UNIT III : MEASURE & ANALYSE PHASE	**(9)**
Decomposition, Principal compound methods, Statistical distributions (non parametric), FMECA (Quantitative model), Reliability (Non normal), Availability, Maintainability (log normal), Risk assessment, Warranty prediction, QCF.	
UNIT IV : DESIGN PHASE	**(9)**
Generate and validate system / sub system models (Field trials), Identifying transfer function, Score cards, Design robustness – Taguchi SN ratio's, Error proofing.	
UNIT V : VALIDATE PHASE	**(9)**
Predicting process performance with Simulation, Testing a design, Statistically confirm build compare Predictions, Supplier - Manufacturing control plans for mean and variance, control charts, Piloting a design.	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Statistical and Managerial Techniques for Six Sigma Methodology, Stefano Barone University of Palermo, Italy and Chalmers University of Technology, Sweden Eva Lo Franco University of Palermo, Italy,1st ed , 2012.
2. Six Sigma for Organizational Excellence, K. Muralidharan, 2015.
3. Six Sigma Demystified, Paul Keller, 2005
4. Six sigma for Dummies, Craig Gygi and Bruce Williams with Neil DeCarlo, John Wiley & Sons, Inc. 2nd ed , 2012.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	-	3	-	1	1	2
2	3	-	-	3	-	1	1	2
3	3	-	-	3	-	1	1	2
4	3	-	-	3	-	1	1	2
5	3	-	-	3	-	1	1	2
CO (W.A)	**3**	**-**	**-**	**3**		**1**	**1**	**2**

22EDX20 ADVANCED STRENGTH OF MATERIALS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

COURSE OBJECTIVES AND OUTCOMES:

	Course Objectives		Course Outcomes
1.0	To understand the deformation of bodies under the different loads.	1.1	Apply the failure theory concepts and stress-strain relationship while designing products.
2.0	To understand dynamics of stresses in various sections.	2.1	Acquire knowledge about shear center, Stresses and deflections in beams.
3.0	To familiarize the students in the curved flexible members and stresses in flat plates.	3.1	Classify Curved flexible members and types of stresses in flat plates.
4.0	To solve problems involving torsion of noncircular sections.	4.1	Calculate the torsion and stresses in sections used in various applications.
5.0	To solve problems involving radial and tangential stresses and contact stresses.	5.1	Demonstrate radial and tangential stresses in solid disc.

UNIT I : ELASTICITY	**(9)**
Stress, stress tensor, stress concentration factor, stress strain relation and general equation of elasticity in cartesion, polar and spherical coordinates, differential equations of equilibrium - compatibility - boundary conditions - representation of three - dimensional stress of a tension generalized hook's law - St. Venant's principle - plane stress - Airy's stress function. Energy methods.	
UNIT II : SHEAR CENTER AND UNSYMMETRICAL BENDING	**(9)**
Location of shear center for various thin sections - shear flows. Stresses and deflections in beams subjected tounsymmetrical loading - kern of a section.	
UNIT III : CURVED FLEXIBLE MEMBERS AND STRESSES IN FLAT PLATES	**(9)**
Curved flexible members, circumference and radial stresses - deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates - pure bending of plates - deflection - uniformly distributed load - various end conditions.	
UNIT IV : TORSION OF NON-CIRCULAR SECTIONS	**(9)**
Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy Prandtl's stress function torsional stress in hollow thin wall tubes.	
UNIT V : STRESSES IN ROTARY SECTIONS AND CONTACT STRESSES	**(9)**
Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness with allowable speeds - Methods of computing contact stress - Deflection of bodies in point and line contact applications.	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Arthur P Boresi, Richard J. Schmidt, "Advanced Mechanics of Materials", New Delhi : Wiley, 2018 , 6th Edition.
2. Timoshenko S P and Goodier J N, "Theory of Elasticity", Chennai McGraw-Hill Education (India) Private Limited 2010, Third edition, India.
3. Srinath. L.S., "Advanced Mechanics of Solids", New Delhi : Tata McGraw-Hill, 2009, 3rd edition
4. G H Ryder, "Strength of Materials", Macmillan, India Ltd, 2007.
5. Robert D. Cook, Warren C. Young, "Advanced Mechanics of Materials", Upper Saddle River : Prentice Hall., 1999 2nd edition.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	2	1	2	-	1	-	-	2
2	1	-	-	3	1	-	1	1
3	2	-	3	2	-	-	-	2
4	2	-	2	1	-	-	1	2
5	2	1	2	-	1	-	-	2
CO (W.A)	**1.8**	**1**	**2.25**	**2**	**1**		**1**	**1.8**

22EDX21 TRIBOLOGY IN DESIGN				
	L	T	P	C
	3	0	0	3

PREREQUISITE : NIL

COURSE OBJECTIVES AND OUTCOMES:

Course Objectives		Course Outcomes	
1.0	To provide greater insight into the science and technology of interacting surfaces in relative motion	**1.1**	Select material / surface properties based on the tribological requirements
2.0	To impart knowledge in the friction, wear and lubrication aspects of machine components	**2.1**	Get Methodology for deciding lubricants and lubrication regimes for different operating conditions
3.0	To understand the analytical behavior of different types of bearings and design of bearings based on analytical /theoretical approach	**3.1**	Get Analysis ability of different types of bearings for given load/ speed conditions.
4.0	To provide greater insight into the science and technology of interacting surfaces in relative motion.	**4.1**	Understand the fundamental principles of thermo hydrodynamic lubrication to determine the temperature distribution in the lubricant film under variable viscosity conditions.
5.0	To give detailed study of contact mechanics and tribo measurements	**5.1**	Familiar with mathematical tools used to analyze tribological processes

UNIT I : SURFACE INTERACTION AND SURFACE TREATMENT	**(9)**
Topography of Surfaces - Surface features - Properties and Measurement - Surface interaction - Surface treatments - Surface modifications - surface coatings methods- Surface Topography measurements - Laser methods - instrumentation - International standards in friction and wear measurements	
UNIT II : WEAR AND FRICTION	**(9)**
Types of wear - Mechanism of various types of wear - Laws of wear -Theoretical wear models - Wear of Metals and Non metals - Adhesive theory of sliding friction - Rolling friction - Friction properties of metallic and Non-Metallic Materials - Friction in extreme conditions - Thermal considerations in sliding contact	
UNIT III : LUBRICANTS AND LUBRICATION REGIMES	**(9)**
Lubricants and their physical properties - Viscosity and other properties of oils – Additives - Selection of Lubricants - Lubricants standards ISO,SAE,AGMA, BIS standards - Lubrication Regimes - Solid Lubrication- Dry and marginally lubricated contacts- Boundary Lubrication - Hydrodynamic lubrication - Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication - Hydro static lubrication - Gas lubrication.	
UNIT IV : THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION	**(9)**
Reynolds Equation,- Assumptions and limitations-One and two dimensional Reynolds Equation - Reynolds and Somerfield boundary conditions - Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings - Long and short bearings - Pad bearings and Journal bearings-Squeeze film effects - Thermal considerations - Hydrostatic lubrication of Pad bearing - Pressure , flow , load and friction calculations - Stiffness considerations- Various types of flow restrictors in hydrostatic bearings.	

UNIT V : CONTACT MECHANICS AND TRIBO MEASUREMENTS	(9)
Contact mechanics, Analysis of contacts, Elastic plastic contact of frictionless solids, problems. Bearing torque calculation, temperature analysis, endurance testing and failure analysis, bearing performance measurements, bearing vibration measurements.	
TOTAL : L : 45 = 45 PERIODS	

REFERENCES:

1. Williams J.A. "Engineering Tribology", Oxford Univ. Press, 1994.
2. S.K.Basu, S.N.Sengupta, B.B.Ahuja, "Fundamentals of Tribology", Prentice–Hall of India Pvt. Ltd., New Delhi, 2005
3. B.C Majumdar, "Introduction to Tribology of bearings", S. Chand and company Ltd., New Delhi 2008.
4. Prasanta Sahoo, "Engineering Tribology", Prentice Hall of India, New Delhi 2005.
5. Rabinowicz.E, "Friction and Wear of materials", John Willey & Sons,UK,1995
6. Cameron, A. "Basic Lubrication Theory", Ellis Herward Ltd., UK, 1981
7. Halling, J. (Editor) – "Principles of Tribology", Macmillian, 1984.
8. G.W.Stachowiak, A.W .Batchelor, "Engineering Tribology", Butterworth-Heinemann, UK, 2005

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	-	2	3	-	3	2
2	3	2	1	2	3	-	3	2
3	-	-	1	-	-	1	3	3
4	3	3	2	2	3	2	3	3
5	3	3	-	2	3	-	3	3
CO (W.A)	3	2.5	1.3	2	3	1.5	3	2.6

22EDX22 NANOMATERIALS AND NANO TECHNOLOGY					
		L	T	P	C
		3	0	0	3
PREREQUISITE :					

Course Objectives		Course Outcomes	
1.0	To impart knowledge on the general issues relating to nanotechnology and nano fabrication.	1.1	Acquire the knowledge of the representatives of nano particles and feature techniques of nano materials.
2.0	To impart knowledge on the methods for 2-D nanostructures	2.1	Familiar with new trends in engineering, namely nanotechnology and nanofabrication and with their applications in modern industries.
3.0	To give detailed study of nanomechanics and nano electronics	3.1	Get knowledge in the field of nano technology and nano materials
4.0	To get a basic understanding of the nanoscale heat transfer and nanophotonics	4.1	Know about mode of heat transfer in nanoparticles and nanomaterials
5.0	To study the fluids at the nano scale	5.1	Understanding nanoscale of fluids and applications of nanofluids

UNIT I : ZERO AND ONE DIMENSIONAL NANOSTRUCTURE- NANOWIRES ANDNANORODS	**(10)**
Nanoparticles through homogenous nucleation, nanoparticles through the heterogeneous nucleation, kinetically confined synthesis of nanoparticles, epitaxial core - shell nanoparticles. Spontaneous growth, template based synthesis, electro spinning, and lithography.	
UNIT II : 2-DIMENSIONAL NANOSTRUCTURES AND FABRICAITON	**(10)**
Fundamentals of film growth, vacuum science, Physical vapor deposition (PVD), Chemical vapor deposition (CVD), Atomic layer deposition (ALD), Electrochemical deposition, Sol-Gel films. Lithography, nano manipulation and nanolithography, soft lithography, assembly of nanoparticles and nanowires, other methods of micro fabrication.	
UNIT III : NANOMECHANICS AND NANO ELECTRONICS	**(10)**
A high speed review of motion: Displacement, velocity, acceleration and force, nano mechanical oscillation, feeling faint forces. Electron energy bands, electrons in solids: conductors, insulation and semi-conductors, fermi energy, the density of states for solids, quantum confinement, tunneling, single electron phenomenon, molecular electronics.	
UNIT IV : NANOSCALE HEAT TRANSFER AND NANOPHOTONICS	**(10)**
Nanoscale heat, conduction, convection, radiation. Photonics properties of nano materials, near - field light, optical tweezers, photonic crystals.	
UNIT V : NANOSCALE FLUID MECHANICS	**(5)**
Fluids at the nanoscale: major concepts, flow fluids flow at the nanoscale, applications of nanofluids.	
TOTAL : L : 45 = 45 PERIODS	

TEXT BOOK:
1. Rogers, Pennathur and Adams, "Nanotechnology: Understanding Small Systems", CRC Press, 3rd edition, 2015. 2. Guozhong Cao and Ying Wang, "Nanostructures and Nanomaterials: Synthesis, Properties, and applications" 2nd edition, World Scientific, 2011.
REFERENCES:
1. Bhushan, Bharat (Ed.) Handbook of Nanotechnology, 3rd edition, Springer 2010. 2. Yury Gogotsi, Nanomaterials Handbook, Drexel University, Philadelphia, Pennsylvania, USA, 2006. 3. Lundstrom, Mark, Guo, Jing, Nanoscale transistors, Device physics, modeling and simulation, Springer, 2006 4. Nanocrystalline Materials by A I Gusev and A ARempel, Cambridge International Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd. 2008.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	1	1	-	-	1	-
2	3	-	1	1	-	-	1	-
3	3	-	1	1	-	-	1	-
4	3	-	1	1	-	-	1	-
5	3	-	1	1	-	-	1	-
CO (W.A)	3	-	1	1	-	-	1	-

22EDX23 MICRO ELECTRO MECHANICAL SYSTEMS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To impart knowledge on MEMS and manufacturing techniques	1.1	The students will be able to identify the needs of micro electromechanical systems
2.0	To get an exposure on the materials for MEMS and micro systems	2.1	The students will be able to develop a knowledge to select materials for Micro systems
3.0	To create exposure to packaging techniques of micro system fabrication processes	3.1	The students will be able to select the suitable fabrication processes for MEMS
4.0	To impart knowledge on micro manufacturing processes	4.1	The students will be able to apply knowledge of micro manufacturing techniques and applications to the design and manufacturing of an MEMS device
5.0	To educate the influence of micro system packaging	5.1	The students will be able to identify the selection of packaging materials of MEMS

UNIT I - INTRODUCTION	(9)
Introduction to MEMS and Microsystems - Typical MEMS and Micro system products - Microsystems and micro electronics - Applications of Microsystems in automotive and other industries - Microsensors - Acoustic wave sensors, Bio medical sensors - Optical sensors, Pressure sensors - Micro actuators - Micro grippers, Micro motors, Micro valves, Micro pumps	
UNIT II - MATERIALS FOR MEMS AND MICROSYSTEMS	**(9)**
Substrates and Wafers - Active substrate materials - Silicon as a substrate material - Silicon compounds - Silicon Dioxide, Silicon Carbide, Silicon Nitride, Polycrystalline Silicon - Silicon Piezoresistors - Gallium Arsenide - Quartz - Polymers - Polymers as Industrial Materials, Polymers for MEMS and Microsystems, Conductive Polymers - Packaging Materials	
UNIT III - MICROSYSTEM FABRICATION PROCESSES	**(9)**
Photolithography - Photoresists and Application, Light Sources, Phoresist Development, Removal and Postbacking - Ion implantation - Diffusion - Oxidation - Chemical Vapor Deposition - Working Principle, Chemical Reactions, Rate of deposition - Physical Vapor Deposition - sputtering	
UNIT IV - MICRO MANUFACTURING	**(9)**
Bulk Micro manufacturing - Etching - Isotropic and Anisotrotpic etching, Wet etching, Dry etching - Surface micromachining - General process, Mechanical problems associated with surface micromachining - LIGA Process general Process, Materials for substrates and photo resists - Electroplating - SLIGA Process.	

UNIT V - MICROSYSTEM PACKAGING	(9)
Mechanical packaging of microelectronics – Micro system packaging - General considerations, Three levels of micro system packaging - Interfaces in micro system packaging - Essential packaging technologies – Die preparation, Surface bonding, Wire bonding - Three dimensional packaging - Assembly of microsystems - Selection of packaging materials	
TOTAL (L:45) : 45 PERIODS	

REFERENCES:

1. Tai-Ran Hsu, "MEMS & Microsystems Design and Manufacture", McGraw Hill Education, 2010
2. Nitaigour Premchand Mahalik, "MEMS", McGraw Hill Education, 2007
3. Gardner, W. Julian, K. Varadan Vijay and O. Awadelkarim, Osama, "Micro sensors MEMS and Smart Devices", Jhon Wiley & Sons Ltd, 2001.
4. Mohamed Gad-el-Hak, MEMS Handbook, CRC Press, 2006.
5. Julian W. Hardner Micro Sensors, Principles and Applications, CRC Press 1993.
6. Marc Madou , Fundamentals of Microfabrication, CRC Press, New York, 1997.
7. Sami Franssila, Introduction to Micro fabrication, John Wiley & sons Ltd, 2004.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	2	2	3	3	2	-	2	-
2	-	-	3	3	3	2	2	3
3	3	3	2	3	2	-	2	2
4	3	2	2	2	3	2	3	2
5	2	-	2	2	2	2	2	-
CO (W.A)	**2.5**	**2.33**	**2.4**	**2.6**	**2.4**	**2**	**2.2**	**2.25**

22EDX24 SURFACE ENGINEERING

L	T	P	C
3	0	0	3

PRE REQUISITE : NIL

	Course Objectives		Course Outcomes
1.0	To impart the knowledge surface damage	1.1	Analyse the surface damage of materials.
2.0	To provide surface metallurgy techniques to improve the surface properties`	2.1	Examine the Surface Metallurgy techniques for altering the surface properties.
3.0	To impart knowledge in various surface treatment process	3.1	Demonstrate the procedures in various surface treatment process
4.0	To give the corrosion knowledge about surface engineering	4.1	Identify the types and classification of corrosion for various surfaces
5.0	To impart the knowledge to characterize the surface	5.1	Analyse the characteristics of surfaces through various metallurgical analysis.

UNIT I : SURFACE DAMAGE (9)

Introduction: Purpose and Need of Surface Engineering, Surface and Sub-surface regions, Classification of Surface Modification Techniques, Scope of Surface Engineering, Role of Surface Properties, Surface Energy. Surface Damage: Factors causing Material Damage, Type of Wear and Mechanisms, Techniques to evaluate Damage of Wear Surfaces. Materials: Material Properties and Wear, Properties required for better Wear Resistance, Selection of Materials for Surface Engineering.

UNIT II : SURFACE METALLURGY (9)

Surface Engineering by changing the Surface Metallurgy: Introduction, Transformation Hardening Methods, Modified Surfaces using LASER and TIG, Plastic Deformation based approaches. Surface Engineering by changing the Composition: Carburizing, Nitriding, Use of Plasma, LASER Alloying, Surface modification using Diffusion-based processes. Surface Modification by Coating and Cladding: Protection and Dilution of Coating and Cladding, Energy density and Cooling rate. Weld surfacing, LASER cladding, Thermal Spraying, Electroplating, Electroless Process.

UNIT III : SURFACE TREATMENT (9)

Introduction - Surface properties, Superficial layer - Wear resistant coatings and Surface treatments - Techniques - PVD - CVD - Physical CVD - Ion implantation - Surface welding - Applications of coatings and surface treatments in wear and friction control - Characteristics of Wear resistant coatings - New trends in coating technology - DLC - CNC - Thick coatings - Nano - engineered coatings - Other coatings, Corrosion resistant coatings.

UNIT IV : CORROSION (9)

Introduction - Principle of corrosion - Classification of corrosion - Types of corrosion - Factors influencing corrosion - Testing of corrosion - In-service monitoring, Simulated service, Laboratory testing - Evaluation of corrosion - Prevention of corrosion - Material selection, Alteration of environment, Design, Cathodic and Anodic protection, Corrosion inhibitors.

UNIT V : CHARACTERIZATION OF SURFACES (9)

Characterization of Engineered Surfaces: Characterization of Surface Properties, Thickness of Coatings and Films, Bond strength of Coating and substrate, Soundness of Modified surfaces by NDT, Destructive Testing of Modified Surfaces, Adhesive Wear, XRD Analysis, SEM, Compositional Analysis, EDAX Analysis, Macroscopic observation and Metallographic Examination.

TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Introduction to Surface Engineering, by P. A. Dearnley, Cambridge University Press
2. Surface Engineering: Enhancing Life of Tribological Components, by D. K. Dwivedi, Springer
3. K.G. Budinski, Surface Engineering for Wear Resistances, Prentice Hall, Englewood Cliffs, 1988
4. ASM Handbook: Surface Engineering, by Faith Reidenback, ASM-International, Metals Park, OH, 1994
5. Advanced Surface Coatings: A Handbook of Surface Engineering, by D. S. Rickerby, A. Mathews, BlackieAcademic and Professional Publ. 1991.
6. Handbook of Thin-Film Deposition Processes and Techniques - Principles, Methods, Equipment and Applications, by K. Seshan, William Andrew Publishing/Noyes, 2002.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	1		1		1	3		
2	2	2	2	2	3	3		2
3	3	2	3	2	3	3		2
4	3	2	3	2	3	3		2
5	3	3	3	3	1	3		3
CO (W.A)	2.4	2.25	2.4	2.25	2.2	3		2.25

22EDX25 ENGINEERING FRACTURE MECHANICS				
	L	T	P	C
	3	0	0	3

PRE REQUISITE :

Course Objectives		Course Outcomes	
1.0	To provide knowledge on elements of solid mechanics.	1.1	Estimate stress, strain and deformation of solid mechanics
2.0	To understand the crack growth and energy balance.	2.1	Analyze crack growth for various loading.
3.0	To study the analysis of energy balance and crack growth mechanics	3.1	Analyze the different effects of cracks, thermal and residual stresses.
4.0	To understand the working principle and analysis of fatigue crack	4.1	Calculate fatigue life for various loading spectrum
5.0	To study the applications of fracture mechanics.	5.1	Applying fracture mechanics concept in large scale yielding.

UNIT I - ELEMENTS OF SOLID MECHANICS	(9)
The geometry of stress and strain, elastic deformation, plastic and elastic-plastic deformation - limit analysis.	
UNIT II - STATIONARY CRACK UNDER STATIC LOADING	**(9)**
Two dimensional elastic zone fields - Analytical solutions yielding near a crack front - Irwin's approximation - Plastic zone size - Dugdaale model -J integral and its relation to crack opening development.	
UNIT III - ENERGY BALANCE AND CRACK GROWTH	**(9)**
Griffith analysis - Linear fracture mechanics -Crack opening displacement - Dynamic energy balance - Crack arrest.	
UNIT IV - FATIGUE CRACK GROWTH CURVE	**(9)**
Empirical Relation describing crack growth by fatigue - life calculations for a given load amplitude - effects of changing the load spectrum - Effects of Environment.	
UNIT V - APPLICATIONS OF FRACTURE MECHANICS	**(9)**
Crack Initiation under large scale yielding - thickness as a design parameter - mixed mode fractures - crack instability in thermal and residual stress fields - numerical methods.	
	TOTAL (L:45) : 45 PERIODS

REFERENCES:

1. Tribikram Kundu, "Fundamentals of Fracture Mechanics", ANE Books Pvt. Ltd. New Delhi / CRC Press, 1st Indian Reprint, 2012
2. David Broek, "Elementary Engineering Fracture Mechanics", Fifthoff and Noerdhoff International Publisher, 1978.
3. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.
4. Preshant Kumar, "Elements of Fracture Mechanics", McGraw Hill Education; 1st edition, 2017.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	2	3	4	5	6	1	2
1	3	3	3	2	2	3	2	2
2	3	2	2	2	2	3	2	2
3	3	-	-	2	-	2	2	2
4	3	2	2	3	3	3	2	2
5	3	2	2	2	2	3	-	2
CO (W.A)	**3**	**2.25**	**2.25**	**2.2**	**2.25**	**2.8**	**2**	**2**

22EDX26 INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS					
			L	T	P	C
			3	0	0	3
PREREQUISITE :					
Course Objectives		**Course Outcomes**			
1.0	To impart the design concepts	**1.1**	Describe the robot kinematics and dynamics.		
2.0	To create expertise in various drive systems of robot.	**2.1**	Create basic program to control robot.		
3.0	To ensure that the student has thorough conceptual understanding of robot sensors.	**3.1**	Demonstrate sensors used in robotics field.		
4.0	This course provides an in-depth coverage of the central topics in robot cell design	**4.1**	Summarize the stages in robot dell design		
5.0	To give the student knowledge about robot programming, and expert systems	**5.1**	Explain the steps involved in robot programming		

UNIT I : INTRODUCTION AND ROBOT KINEMATICS	**(9)**
Definition need and scope of Industrial robots - Robot anatomy - Work volume - Precision movement - End effectors - Sensors. Robot Kinematics - Direct and inverse kinematics - Robot trajectories - Control of robotmanipulators - Robot dynamics - Methods for orientation and location of objects.	
UNIT II : ROBOT DRIVES AND CONTROL	**(9)**
Controlling the Robot motion - Position and velocity sensing devices - Design of drive systems - Hydraulic and Pneumatic drives - Linear and rotary actuators and control valves - Electro hydraulic servo valves, electric drives- Motors - Designing of end effectors - Vacuum, magnetic and air operated grippers.	
UNIT III : ROBOT SENSORS	**(9)**
Transducers and Sensors - Tactile sensor - Proximity and range sensors - Sensing joint forces - Robotic vision system Image Representation - Image Grabbing - Image processing and analysis - Edge Enhancement - Contrast Stretching Band Rationing - Image segmentation - Pattern recognition - Training of vision system.	
UNIT IV : ROBOT CELL DESIGN AND APPLICATION	**(9)**
Robot work cell design and control - Safety in Robotics - Robot cell layouts - Multiple Robots and machine interference - Robot cycle time analysis - Industrial application of robots.	
UNIT V: ROBOT PROGRAMMING, AI AND EXPERT SYSTEMS	**(9)**
Methods of robot programming - Characteristics of task level languages - lead through programming methods - Motion interpolation. Artificial intelligence - Basics - Goals of artificial intelligence - AI techniques - problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots.	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey, "Industrial Robotics Technology, Programming and Applications", McGraw-Hill Int. 2017.
2. Deb, S.R. "Robotics Technology and Flexible Automation", Tata McGraw-Hill, 2009.
3. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, "Robotics Control, Sensing, Vision and Intelligence", McGraw Hill, 1987.
4. YoramKoren, "Robotics for Engineers", McGraw-Hill, 1987.
5. Kozyrey, Yu. "Industrial Robots", MIR Publishers Moscow, 1985.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme SpecificOutcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	3	1	1	3	-	3	3	1
2	3	1	1	3	-	3	3	1
3	3	1	1	3	-	3	3	1
4	3	1	1	3	-	3	3	1
5	3	1	1	3	-	3	3	1
CO (W.A)	**3**	**1**	**1**	**3**	**-**	**3**	**3**	**1**

22EDX27 PRODUCT LIFECYCLE MANAGEMENT					
		L	T	P	C
		3	0	0	3
PRE REQUISITE :					

Course Objectives		Course Outcomes	
1.0	To understand history, concepts and terminology of PLM	**1.1**	Understand history, concepts and terminology of PLM.
2.0	To understand functions and features of PLM / PDM	**2.1**	Apply the functions and features of PLM/PDM.
3.0	To understand different modules offered in commercial PLM / PDM tools	**3.1**	Understand different modules offered in commercial PLM/PDM tools.
4.0	To understand PLM / PDM implementation approaches	**4.1**	Understand PLM/PDM implementation approaches.
5.0	To understand integration of PLM / PDM with other applications	**5.1**	Integrate PLM/PDM with other applications.

UNIT I : HISTORY, CONCEPTS AND TERMINOLOGY OF PLM	**(9)**
Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM).PLM/PDM Infrastructure -Network and Communications, Data Management, Heterogeneous data sources and applications.	
UNIT II : PLM/PDM FUNCTIONS AND FEATURES	**(9)**
User Functions - Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions - Communication and Notification, data transport, data translation, image services, system administration and application integration.	
UNIT III : DETAILS OF MODULES IN A PDM/PLM SOFTWARE	**(9)**
Case studies based on top few commercial PLM/PDM tools	
UNIT IV : ROLE OF PLM IN INDUSTRIES	**(9)**
Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organisation, users, product or service, process performance.	
UNIT V : BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE	**(9)**
PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP	
TOTAL : L: 45 = 45 PERIODS	

REFERENCES:

1. Antti Saaksvuori and Anselmi Immonen, "Product Lifecycle Management", Springer Publisher, 2008 (3rd Edition).
2. International Journal of Product Lifecycle Management, Inderscience Publishers
3. Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product DataManagement and Software Configuration Management", Artech House Publishers, 2003.
4. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
5. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher,2011 (2nd Edition).
6. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	-	-	3	-	1	1	2
2	3	-	-	3	-	1	1	2
3	3	-	-	3	-	1	1	2
4	3	-	-	3	-	1	1	2
5	3	-	-	3	-	1	1	2
CO (W.A)	**3**	**-**	**-**	**3**		**1**	**1**	**2**

22BAZ01 - RESEARCH METHODOLOGY AND IPR					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			
1.0	To understand the basic concepts of research and its methodologies, investigation of solutions for research problem, data collection, analysis and interpretation.	**1.1**	Demonstrate the concepts of research and its methodologies, Approaches of information investigation of solutions for research problem, data collection, analysis and interpretation.		
2.0	To identify the various procedures to collect literature studies approaches analysis, plagiarism, and research ethics.	**2.1**	Formulate effective literature studies approaches, analysis, plagiarism, and research ethics.		
3.0	To inculcate knowledge on Effective technical writing and method to write report.	**3.1**	Identify the design for Effective technical writing and how to write report.		
4.0	To provide knowledge process like drawing and drafting tools and reviewing research papers.	**4.1**	Choose the process like drawing and drafting tools and reviewing research papers.		
5.0	To summarize the design for Intellectual property rights and code of ethics.	**5.1**	Formulate the design for Intellectual property rights and code of ethics.		

UNIT I - RESEARCH PROBLEM FORMULATION	**(9)**
Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations.	
UNIT II - LITERATURE REVIEW	**(9)**
Effective literature studies approaches, analysis, plagiarism, and research ethics	
UNIT III - TECHNICALWRITING /PRESENTATION	**(9)**
Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.	
UNIT IV - INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR)	**(9)**
Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	

UNIT V - INTELLECTUAL PROPERTY RIGHTS (IPR)	(9)
Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. Cooper, D. R. and Schindler, P. S., (2009), "Business Research Methods", Tata McGraw Hill, 9th Edition.
2. Krishnaswamy, K.N., Sivakumar, A.I., and Mathirajan, M., "Management Research Methodology", Pearson Education, 2006.
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.

REFERENCES :

4. Jackson, S.L., "Research Methods and Statistics", Cengage Learning India Private Limited, New Delhi, 2009
5. Lebrun, J-L., "Scientific Writing: A Reader and Writer's Guide", World Scientific Publishing Co. Pte. Ltd., Singapore, 2007.
6. Nicholls, David G, "MLA Handbook for Writers of Research papers", Seventh Edition, Affiliated East West Press Pvt Ltd, New Delhi, 2009.
7. Thiel, D. V., "Research Methods for Engineers", Cambridge University Press, 2014.
8. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" ,2010.

Mapping of COs with POs / PSOs

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	1	1	2	1	3	-
2	2	3	2	1	-	-	2	1
3	2	3	2	2	1	1	2	1
4	1	3	2	2	2	1	1	2
5	1	1	2	3	2	2	1	2
CO (W.A)	**1.8**	**2.4**	**1.8**	**1.8**	**1.75**	**1.25**	**1.8**	**1.5**

22CPZ01- MACHINE VISION					
		L	T	P	C
		3	0	0	3
PRE REQUISITE : NIL					
Course Objectives		**Course Outcomes**			
1.0	To know the basics of machine vision and computer vision.	**1.1**	The student will be able to apply the vision concepts in various mechatronics applications.		
2.0	To study the image acquisition techniques.	**2.1**	The student will be able to recognize the Image acquisition techniques and tools.		
3.0	To learn the image processing methods.	**3.1**	The student will be able to apply the image processing tools and libraries.		
4.0	To understand the methods used for image analysis.	**4.1**	The student will be able to analyze the images in the case of Robotic or IoT applications.		
5.0	To gain exposure on Image processing applications.	**5.1**	The student will be able to select the right machine vision system for implementing in industrial applications.		

UNIT I - INTRODUCTION	**(8)**
Human vision – Machine vision and Computer vision – Benefits of machine vision – Block diagram and function of machine vision system implementation of industrial machine vision system – Physics of Light – Interactions of light – Refraction at a spherical surface.	
UNIT II - IMAGE ACQUISITION	**(12)**
Scene constraints – Lighting parameters – Lighting sources, Selection – Lighting Techniques – Types and Selection – Machine Vision Lenses and Optical Filters, Specifications and Selection Imaging Sensors – CCD and CMOS, Specifications – Interface Architectures – Analog and Digital Cameras – Digital Camera Interfaces – Camera Computer Interfaces, Specifications and election – Geometrical Image formation models – Camera Calibration.	
UNIT III - IMAGE PROCESSING	**(10)**
Machine Vision Software – Fundamentals of Digital Image – Image Acquisition Modes – Image Processing in Spatial and Frequency Domain – Point Operation, Thresholding, Grayscale Stretching – Neighborhood Operations, Image Smoothing and Sharpening – Edge Detection –Binary Morphology – Color image processing.	
UNIT IV - IMAGE ANALYSIS	**(6)**
Feature extraction – Region Features, Shape and Size features – Texture Analysis – Template Matching and Classification – 3D Machine Vision Techniques – Decision Making.	

UNIT V - MACHINE VISION APPLICATIONS	(9)
Machine vision applications in manufacturing, electronics, printing, pharmaceutical, textile, applications in non-visible spectrum, metrology and gauging, OCR and OCV, vision guided robotics – Field and Service Applications – Agricultural, and Bio medical field, augmented reality, surveillance, bio-metrics.	
TOTAL (L:45) : 45 PERIODS	

TEXT BOOK:

1. D. A. Forsyth and J. Ponce, "Computer Vision: A Modern Approach", Pearson Education, 2003.
2. R. Jain, R. Kasturi and B. G. Schunck, "Machine Vision", McGraw-Hill, 1995.
3. Dana H. Ballard & Christopher M. Brown, "Computer Vision", Prentice-Hall, 1982.
4. Alexander Hornberg, "Handbook of Machine Vision", First Edition.2007.
5. Emanuele Trucco, Alessandro Verri, "Introductory Techniques For 3D Computer Vision", First Edition

Mapping of COs with POs / PSOs

COs	POs						PSOs	
	1	2	3	4	5	6	1	2
1	3	2	-	1	1	3	2	2
2	3	2	2	1	1	3	2	2
3	3	2	3	2	1	3	2	3
4	3	2	2	1	1	3	2	2
5	3	3	3	3	3	3	3	3
CO (W.A)	3	2.2	2.5	1.6	1.4	3	2.2	2.4

22PGA01 ENGLISH FOR RESEARCH PAPER WRITING				
	L	T	P	C
	2	0	0	0

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To make the students to improve writing skills and level of readability	**1.1**	The students will be able to improve writing skills and level of readability
2.0	To explain the strategic planning process and apply different presentation method	**2.1**	The students will be able to describe what to write in each section
3.0	To foster the ability to understand and to utilize the mechanics of writing	**3.1**	The students will be able to explain the skills needed for writing quality research paper
4.0	To Infer the skills needed when writing the Conclusion	**4.1**	The students will be able to explore the recent areas of research
5.0	To focus research and its key variables, guiding through research process	**5.1**	The students will be able to illustrate the good quality of paper at very first-time submission

UNIT I - INTRODUCTION	**(6)**
Planning and Preparation - Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness	
UNIT II - PRESENTATION SKILLS	**(6)**
Clarifying Who Did What- Highlighting Findings - Hedging and Criticizing- Paraphrasing - Sections of a Paper –Abstracts - Introduction	
UNIT III- MECHANICS OF RESEARCH	**(6)**
Key skills needed for writing - Title, Abstract, Introduction, Discussion, Conclusion, The Final Check	
UNIT IV - PROCESS OF RESEARCH WRITING	**(6)**
Skills needed for writing Methods - skills needed when writing Results - skills needed when writing Discussion - skills needed when writing Conclusion.	
UNIT V- QUALITY RESEARCH PAPER	**(6)**
Useful phrases, Checking Plagiarism - Bibliography- Citation- how to ensure paper is as good as it could possibly be the first- time submission	
TOTAL (L:30) :30 PERIODS	

REFERENCES:

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

22PGA02 DISASTER MANAGEMENT				
	L	T	P	C
	2	0	0	0

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To Summarize basics of disaster	**1.1**	Ability to summarize basics of disaster
2.0	To Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response	**2.1**	Ability to explain a critical understanding of key concepts in disaster risk reduction and Humanitarian response.
3.0	To Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.	**3.1**	Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
4.0	To Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.	**4.1**	Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations
5.0	To Develop the strengths and weaknesses of disaster management approaches	**5.1**	Ability to develop the strengths and weaknesses of disaster management approaches

UNIT I - INTRODUCTION	**(6)**
Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.	
UNIT II - REPERCUSSIONS OF DISASTERS AND HAZARDS	**(6)**
Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.	
UNIT III- DISASTER PRONE AREAS IN INDIA	**(6)**
Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics.	
UNIT IV - DISASTER PREPAREDNESS AND MANAGEMENT	**(6)**
Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.	
UNIT V- RISK ASSESSMENT	**(6)**
Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival	
TOTAL (L:30) :30 PERIODS	

REFERENCES:

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi, 2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company, 2007.
3. Sahni, PardeepEt.Al. ," Disaster Mitigation Experiences and Reflections", Prentice Hall Of India, New Delhi, 2001.

22PGA03 CONSTITUTION OF INDIA				
	L	T	P	C
	2	0	0	0

PRE REQUISITE : NIL

Course Objectives		Course Outcomes	
1.0	To understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.	**1.1**	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2.0	To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional	**2.1**	Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
3.0	To role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.	**3.1**	Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution..
4.0	To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.	**4.1**	Discuss the passage of the Hindu Code Bill of 1956.
1.0	To understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.	**1.1**	Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.

UNIT I - HISTORY OF MAKING OF THE INDIAN CONSTITUTION	**(6)**
History, Drafting Committee, (Composition & Working)	
UNIT II - PHILOSOPHY OF THE INDIAN CONSTITUTION	**(6)**
Preamble, Salient Features	
UNIT III- ONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES	**(6)**
Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.	
UNIT IV - LOCAL ADMINISTRATION	**(6)**
District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy.	
UNIT V- ELECTION COMMISSION	**(6)**
Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.	
TOTAL (L:30) :30 PERIODS	

REFERENCES:

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

22EDX28 FUEL CELL TECHNOLOGY

L	T	P	C
3	0	0	3

PRE REQUISITE : Nil

Course Objectives		Course Outcomes At the end of course, the students will be able to	
1.0	To impart knowledge about the various types of fuel cells	1.1	Explain the various fuel cell types with their merits and demerits.
2.0	To learn the basic electrochemical principles of fuel cell	2.1	Describe the electrochemical principles, reactions and basic laws of fuel cell
3.0	To know the components, materials and operating conditions of fuel cell	3.1	interpret the various components, materials and operating conditions used in fuel cell.
4.0	To provide fundamental knowledge of Hydrogen usage on fuel cells	4.1	Outline the different modes of generation, storage and delivery of Hydrogen
5.0	To provide an exposure on the applications of fuel cells	5.1	Apply the different types of fuel cell systems for various applications

UNIT I : FUEL CELLS TYPES (9)

Introduction to fuel cells – Comparison of fuel cell, I.C. Engine and battery – working of fuel cell - Types of fuel cells – Alkaline Fuel Cell, Phosphoric Acid Fuel Cell, Proton Exchange Membrane Fuel Cell, Molten Carbonate Fuel Cell, Solid Oxide Fuel Cell, Direct Methanol Fuel Cell, Biologically based fuel cell.

UNIT II : ELECTROCHEMICAL PRINCIPLES (9)

Electrochemical reactions – Scientific Units, Constants and Basic Laws – Faraday's Law - Measure of reactant utilization efficiency - Generic fuel cell - thermodynamics of fuel cell process – performance evaluation of fuel cell.

UNIT III : PEMFC - COMPONENTS, MATERIALS AND OPERATING CONDITIONS (9)

Components and materials of PEMFC – Membrane, Catalyst, GDL, Flow field plate, Current collector, End plate – Operating conditions – Pressure, temperature, flow rate, humidity, mass balance, other factors – single cell and stack

UNIT IV : HYDROGEN USAGE (9)

Hydrogen – physical and chemical properties, salient characteristics - Modes of hydrogen generation - Modes of hydrogen storage – hydrogen delivery – overall hydrogen infrastructure development

UNIT V : FUEL CELL APPLICATIONS (9)

Concepts of EV and FCEV – Fuel cell applications – Transportation – stationery power – backup power - Fuel Cells for Small Portable Power.

TOTAL (L:45) : 45 PERIODS

TEXT BOOKS:

1. Frano Barbir, "PEM Fuel Cells : Theory and practice", 2nd Ed., Elsevier Academic Press, USA, 2013
2. Matthew M. Mench, "Fuel Cell Engines", John Wiley & Sons, 2008

REFERENCES:

1. Andrew L. Dicks, David A. J. Rand, "Fuel Cell Systems Explained" 3rd Ed., Wiley 2018
2. Pasquale Corbo, Fortunato Migliardini, Ottorino Veneri, "Hydrogen Fuel Cells for Road Vehicles - Green Energy and Technology (GREEN)", Springer, 2011
3. Viswanathan B. and Aulice Scibioh.M, Fuel Cells – Principles and Applications, Universities Press, 2006.

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	1	-	1	2	-	2	1	-
2	2	-	2	2	-	2	1	-
3	3	-	3	2	2	2	3	2
4	3	-	3	2	2	2	3	2
5	3	-	3	2	2	2	3	2
CO (W.A)	**2.4**	**-**	**2.4**	**2**	**1.2**	**2**	**2.2**	**2**

*** To be ratified in the 12 th BoS meeting**

22EDX29 ENERGY RESOURCES

L	T	P	C
3	0	0	3

PRE REQUISITE : Nil

Course Objectives		Course Outcomes (At the end of course, the students will be able to)	
1.0	To understand the concepts of various forms of Nonrenewable and renewable energy sources.	1.1	Interpret the various energy sources and energy scenario
2.0	To learn the bio energy sources and its processing	2.1	Describe the bio energy resources, conversion and new products developed for various applications
3.0	To study the wind power and the conversion devices and applications	3.1	Explain the wind power generation, conversion devices, offshore wind energy and hybrid systems
4.0	To impart knowledge about solar energy and solar cells	4.1	Demonstrate the power generation using solar cells and their applications
5.0	To provide an exposure on the power generation using fuel cells, OTEC and other energy sources	5.1	interpret the different energy sources like fuel cells, OTEC, ocean wave and geothermal

UNIT I : ENERGY SOURCES AND SCENARIO (9)

Renewable and Non-renewable energy sources - Coal, Oil, Gas, Nuclear and Hydro power – generation and utilization in the past, present and future projections – impact of fossil fuels on environment – Energy scenario in India – Growth of energy sector and its planning in India.

UNIT II : BIO ENERGY SOURCE (9)

Bio energy - Biomass resources and their classification - Biomass conversion processes - types of biogas Plant - applications - alcohol production from biomass – bio diesel production – Urban waste to energy conversion - Biomass energy programme in India – E20 concept.

UNIT III : WIND ENERGY SOURCE (9)

Nature of the wind – power in the wind – factors influencing wind – wind data and energy estimation - wind speed monitoring - site selection - wind energy conversion devices - classification, applications – offshore wind energy - Hybrid systems - wind energy potential and installation in India – Repowering concept.

UNIT IV : SOLAR ENERGY SOURCE (9)

Solar radiation at the earth's surface – solar radiation measurements –flat plate and concentrating collectors – solar thermal applications - heating, cooling, desalination, drying, cooking, etc. – solar thermal electric power plant - principle of photovoltaic conversion of solar energy, types of solar cells - Photovoltaic applications - solar PV power plant – Net metering concept.

UNIT V : FUEL CELL AND OTHER ENERGY SOURCES (9)

Fuel cell– principle of working - types - construction and applications - Hydrogen production and storage-Principle of ocean thermal energy conversion (OTEC) - ocean thermal power plant - ocean wave energy conversion - tidal energy conversion – small hydro – geothermal energy - geothermal power plant

TOTAL (L:45) : 45 PERIODS

TEXT BOOKS:

1. Bob Everett, Stephen Peake, James Warren, "Energy Systems And Sustainability: Power for a Sustainable Future", OUP Oxford, 3rd Ed., 2021.
2. Bent Sorensen, "Renewable Energy", Elsevier, Academic Press, 5th Ed., 2017.

REFERENCES:

1. Stephen Peake, "Renewable Energy: Power for a sustainable future", Oxford University Press, 2018
2. Peter Gevorkian, "Sustainable Energy Systems Engineering," McGraw-Hill, 2007.
3. Kishore V.V.N., "Renewable Energy Engineering and Technology: Principles and Practice", Teri Press, 2009

Mapping of Course Outcomes (COs) with Programme Outcomes (POs) / Programme Specific Outcomes (PSOs)

Mapping of COs with POs / PSOs								
COs	**POs**						**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**
1	2	-	2	2	1	2	2	1
2	2	-	2	2	2	2	2	1
3	2	-	2	2	2	2	2	1
4	2	-	2	2	2	2	2	1
5	2	-	2	2	2	2	2	1
CO (W.A)	**2**	**-**	**2**	**2**	**1.8**	**2**	**2**	**1**

*** To be ratified in the 12 th BoS meeting**